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TRENDS AND CYCLES IN THE PRODUCTION OF RAYON

A STUDY OF VISCOSE[**] FILAMENT YARN PRODUCTION IN THE UNITED STATES, 1911--1948

By Edward R. Dewey

Summary: This paper describes the successive isolation of 2-year, 2 3/4-year, 3 1/2-year, and 6-year cycles in the production of viscose rayon filament yarn, 1911-1949. It adjusts the figures for these cycles to obtain an approximation of the underlying growth trend. It projects the cycles into the future and combines them to show the deviation from trend that will occur if the cycles continue. The paper is intended as an example of a simple cycle analysis. It includes all arithmetic so that the processes of analysis and synthesis can be followed easily.

Part I. The Data

The growth of viscose[**] rayon filament yarn production from its beginning in 1911 to the present time has been called one of the seven wonders of the industrial world.[1]

During the entire period under review, production failed to increase only four years (1918, 1932, 1934, and 1938). The over-all growth from 400,000 pounds in 1911 to 562,300,000 pounds in 1948 shows a gain of over a thousandfold in less than two generations. Year-by-year figures are given in Table 1 and plotted on arithmetic scale in Figure 1.

Rate of Growth Declining

If we study trends and cycles, however, it is necessary to plot the figures on ratio (or **semi-logarithmic**) scale (Figure 2).[***] One advantage of such a plotting is that it shows directly the falling-off in the rate of growth, and permits making visual or freehand projections into the future that are much more likely to be reliable than would be any similar projection of a chart on ordinary arithmetic scale.

The growth of viscose rayon filament yarn production over the years has been dramatic, yet the fact that the curve no longer rises as rapidly as formerly demonstrates immediately that the rate of growth is slowing down.

Percentage comparisons substantiate this. From 1946 to 1947, for example, the production increased 6.9 percent. But from 1936 to 1937 production increased 10.8 percent; from 1926 to 1927, 17.1 percent; from 1919 to 1920, 22.0 percent; and from 1913 to 1914, 33.3 percent. (Percentage growth for each year, in comparison with the year before, is shown in Table 2.) It would be interesting to make a detailed study of the growth, but this is impossible until we have studied the cycles. Underlying growth trends can **never** be properly studied until the cycles have been determined and adjustments made to take account of them.

Four Cycles in Rayon Production

If the rayon figures are analysed for cycles or rhythms, it will be found that from the beginning the figures act as if the trend had been influenced by four well-known rhythmic forces. From crest to crest, one of these series of repetitive waves is about 2 years long, one is about 2 3/4 years long, another is about 3 1/2 years long, and still another is about 6 years long. In a sense the curve acts as if it were pushed up and down around the underlying growth trend by the composite force of these four rhythmic influences, and of course, by accidental forces, such as war.

Part II. The 2-Year Rhythm

Careful observation of Figure 2 shows that from the beginning there has been a tendency for growth to be greater in odd than in even years. For example: start in 1939 and count backwards: High, low; high, low; high (relative to trend), low; and so forth. This rhythmic tendency can be more easily seen if we insert a moving average trend line (shown by the broken line in Figure 2) and observe the years in which the production is over or under the trend. Figures for the moving average trend are given in Table 3.

Relation of Production Figures to 2-Year Trend

The 2-year rhythm can be seen even more easily if we compute the percentages that the actual figures are of the trend and plot them by themselves. Observe the solid line in Figure 3: the effect of this computation is to convert the trend into a straight horizontal line or, as it were, to pull it level. Figures for the percentages are given in Table 4.

To Figure 3 has been added, by means of a broken line, a perfectly regular 2-year wave to help follow the 2-year pattern and to help disclose those places where the 2-year wave has failed to dominate the situation. Up to the war there were three such places: production in 1916 was "too big," and in 1921 and 1927 "too little." If in those three years, other factors had not upset the 2-year pattern, the 2-year pattern would have been perfect from 1911 up to the war. The 2-year rhythm largely disappeared with the coming of the war, but even so there seems to be a vestige of it left.

The broken line in Figure 2 is a two-year moving

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[*] BASED UPON A REPORT PREPARED IN MIMEOGRAPH FORM BY THE FOUNDATION FOR THE STUDY OF CYCLES IN 1949.

[**] WHENEVER THE WORD "VISCOSE" APPEARS IN THIS REPORT IT IS UNDERSTOOD TO INCLUDE NITROCELLULOSE PROCESS RAYON YARN UNTIL ITS PRODUCTION WAS DISCONTINUED IN 1934, AND ALSO TO INCLUDE THE PRODUCTION OF CUPRAMMONIUM FILAMENT YARN FROM ITS FIRST PRODUCTION TO DATE.

[***] FOR A FULL DISCUSSION OF THE RATIO SCALE, MOVING AVERAGES, TRENDS, AND CYCLES, SEE REFERENCES 2 AND 3.

[1] THIS REFERENCE AND ALL OTHERS ARE INCLUDED AT THE END OF THE REPORT.

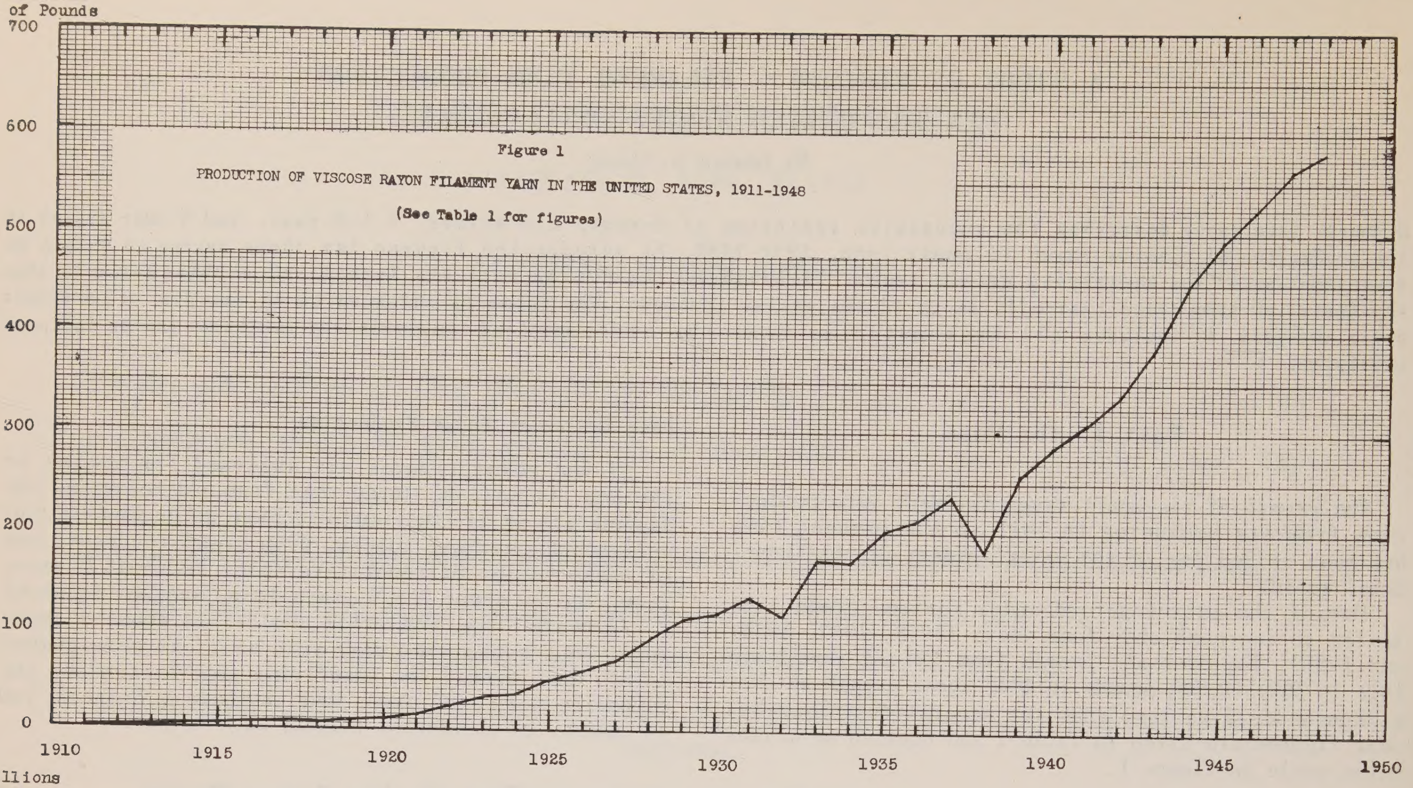


Figure 1

PRODUCTION OF VISCOSE RAYON FILAMENT YARN IN THE UNITED STATES, 1911-1948

(See Table 1 for figures)

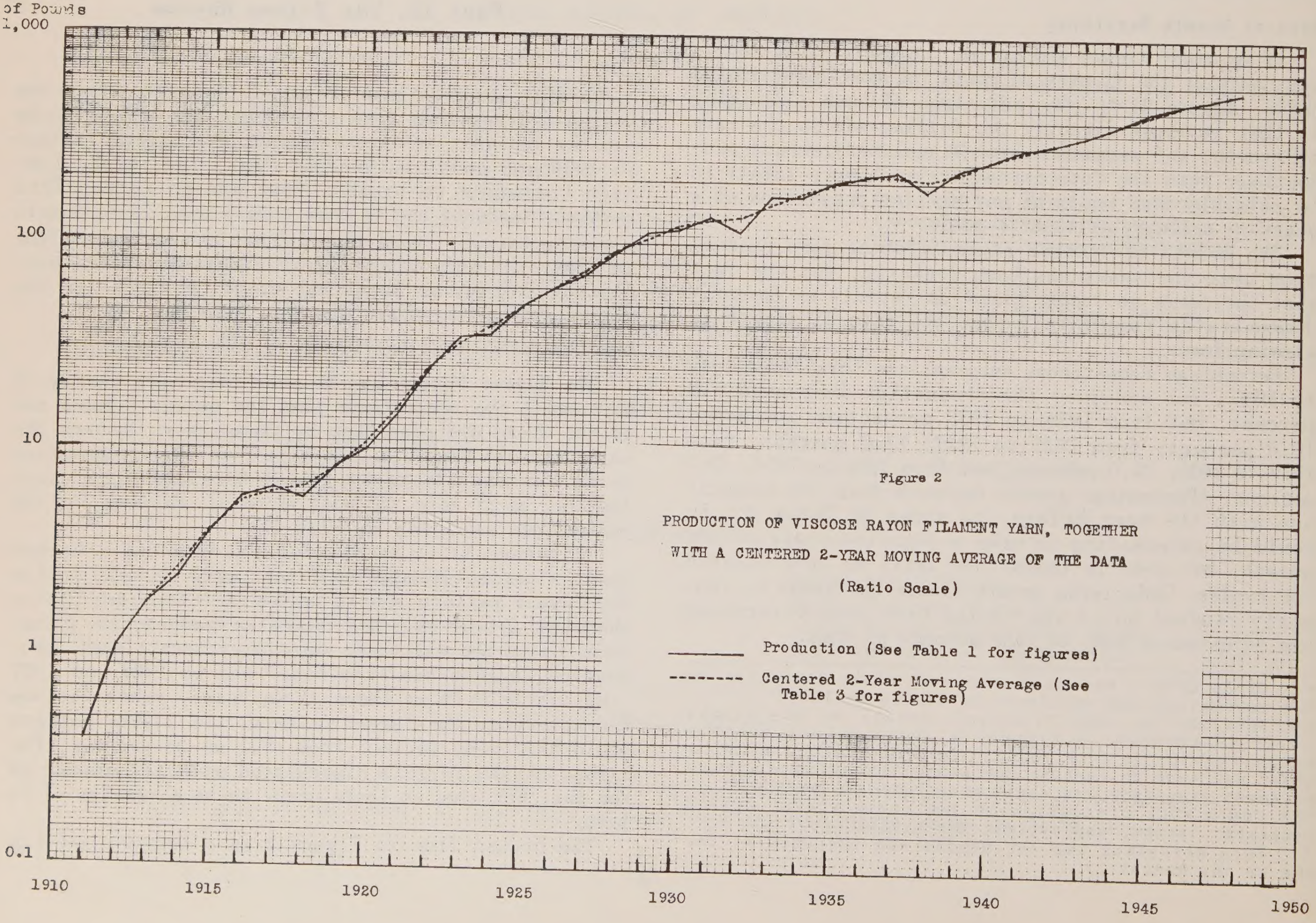


Figure 2

PRODUCTION OF VISCOSE RAYON FILAMENT YARN, TOGETHER WITH A CENTERED 2-YEAR MOVING AVERAGE OF THE DATA

(Ratio Scale)

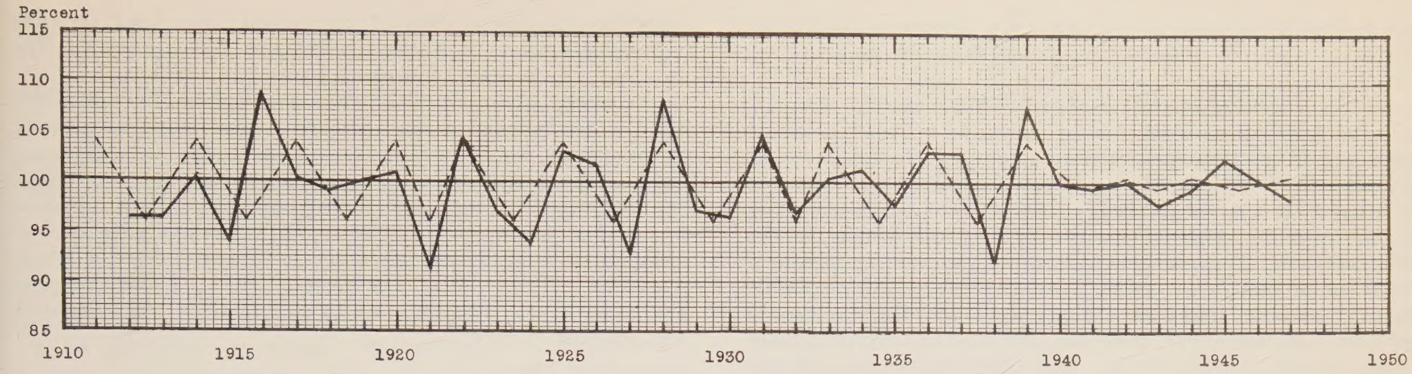


Figure 13

THE 2 3/4-YEAR RHYTHM IN THE PRODUCTION OF VISCOSE RAYON FILAMENT YARN

——— Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effects of the 2-Year, 3 1/2-Year and 6-Year Rhythms, Are of the 3-Year Moving Average of the Same.

------- Diagrammatic Representation of a Perfectly Regular Rhythm with Peaks at 3-, 3-, 3-, 2-Year Intervals, Based on 1911 and Repeating Every 11 Years.

average of a 2-year moving average. The effect of such a computation is to eliminate any 2-year wave that might be present in the original figures.[3] Then, by comparing the original figures (which have the 2-year wave still in them) with the trend (from which the 2-year waves have been smoothed out) we get the figures plotted in Figure 3, in which the 2-year wave can be seen largely by itself.

A rhythm of about 2 years is present in many industrial figures, and has also been reported in weather and other natural phenomena.[4] As yet, no one knows its cause, but this fact does not prevent use of this information.

Amplitude of the 2-Year Wave

From 1912 to World War II the average over-all amplitude of the 2-year wave was 7.6 percent. From 1940 through 1947 it was 0.6 percent. (For details of computation, see Table 5.) If, in future years, the 2-year tendency resumes with its old-time vigor-(For after a distortion, or artificial damping, these waves generally do) important differences in alternate years owing to this 2-year force can be expected.

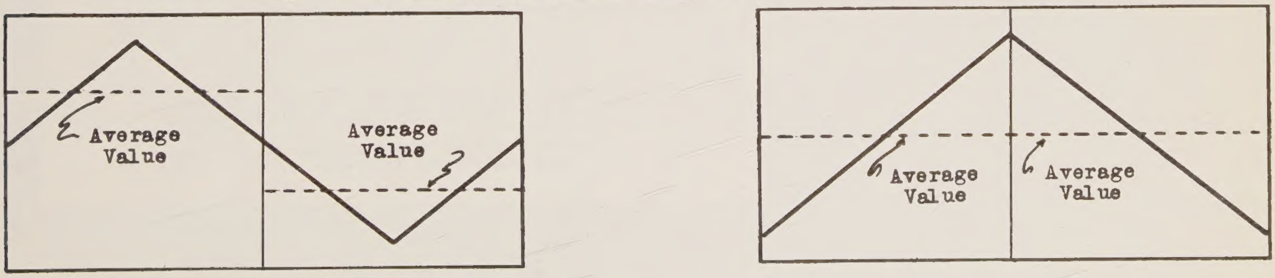
Length of the 2-Year Wave

From a study of the annualfigures alone it is impossible to say whether or not the wave is exactly 2 years in length. A study of monthly figures of viscose rayon deliveries, 1923 to 1936 inclusive, however, indicates that the series has a rhythm of about 24 1/4 months.[5] It is possible that a similar study of monthly figures of viscose filament yarn production from 1911 to 1948 would show a rhythm of similar length.

If, in any series, the peaks of the 2-year rhythm come in the middle of even years, or vice versa, the wave will show up clearly in the annual figures. If, on the other hand, the crests and troughs come at year-end, the **annual** figures will show nothing, even though the wave is still fully operative. (See Figure 4.)

If the rhythm really is 24 1/4 months, it will thus gradually fade out of the annual averages, even though it remains in full force in the monthly figures. It will "slip" forward one month every four cycles (eight years), and move forward six months from a position of maximum effect on the annual figures to one of no effect at all on the annual figures in six times eight,

Figure 4. DIAGRAMMATIC REPRESENTATION OF A 2-YEAR WAVE



A. Annual Effect When Peaks Come at the Middle of a Year: Yearly Averages for First and Second Year Differ.

B. Annual Effect When Peaks Come at the End of a Year: Yearly Averages for First and Second Years Are the Same.

or forty-eight, years. For accurate forecasting, therefore, a study of the monthly figures is important.

Part III. The 3 1/2-Year Rhythm

The 3 1/2-year wave can be detected statistically in the original figures and even by a trained eye in Figure 2 (a chart of the "raw" production figures plotted on ratio ruling). But it will appear more clearly after the elimination of the effect of the 2-year wave. This has been done by increasing the production figures for every even year from 1911 to 1939 by 3.8 percent (half of 7.6 percent) and decreasing the production for every odd year during the period by the same amount. Similarly we increase even-numbered war and post-war years from 1940 to 1948 by 0.3 percent, and decrease odd-numbered years during this period by a like percentage. The result is recorded in Table 6 and plotted on ratio scale in Figure 5 by a solid line.

Emergence of 3 1/2-Year Wave

Starting with 1937 as a peak year and counting backwards, indicates highs relative to trend at 4-, 3-, 4-, 3-, 4-, 3-year intervals.

It will be easier to follow the technique outlined in Part II, however, and to compute a 3-year moving average trend of these corrected figures (Table 7), thus plotted as a broken line on Figure 5. The percentages which the values of the solid line bear to this moving average are shown in Table 8 and Figure 6. The 4-, 3-, 4-, 3-year tendency is clearly evident.

It seems probable that this average 3 1/2-year wave is the well-established 41-month rhythm so universal in American industry.[6] It has been found in more than half of some 500 price and production series that have been studied by various investigators.[2] This assumption of a 41-month length in this series should, be checked by a study of the monthly figures. Such a study would involve at least twice the work of the present investigation, however and is not within the scope of the present report.

Seven-Year Phase

A moment's reflection will show that if a perfectly regular 3 1/2-year wave exists it will be seven years before it will again come around to the same phase relationship with the calendar year. This fact is illustrated by Figure 7. Percentages up to World War II, therefore, were thrown into a seven-year periodic table (Table 9), which table represents the 3 1/2-year wave listed twice. An average (mean or median) of those values represents the average successive annual effect of the 3 1/2-year wave.

I see no evidence of the 3 1/2-year waves from 1940 to 1948, but arbitrarily assume that they are present

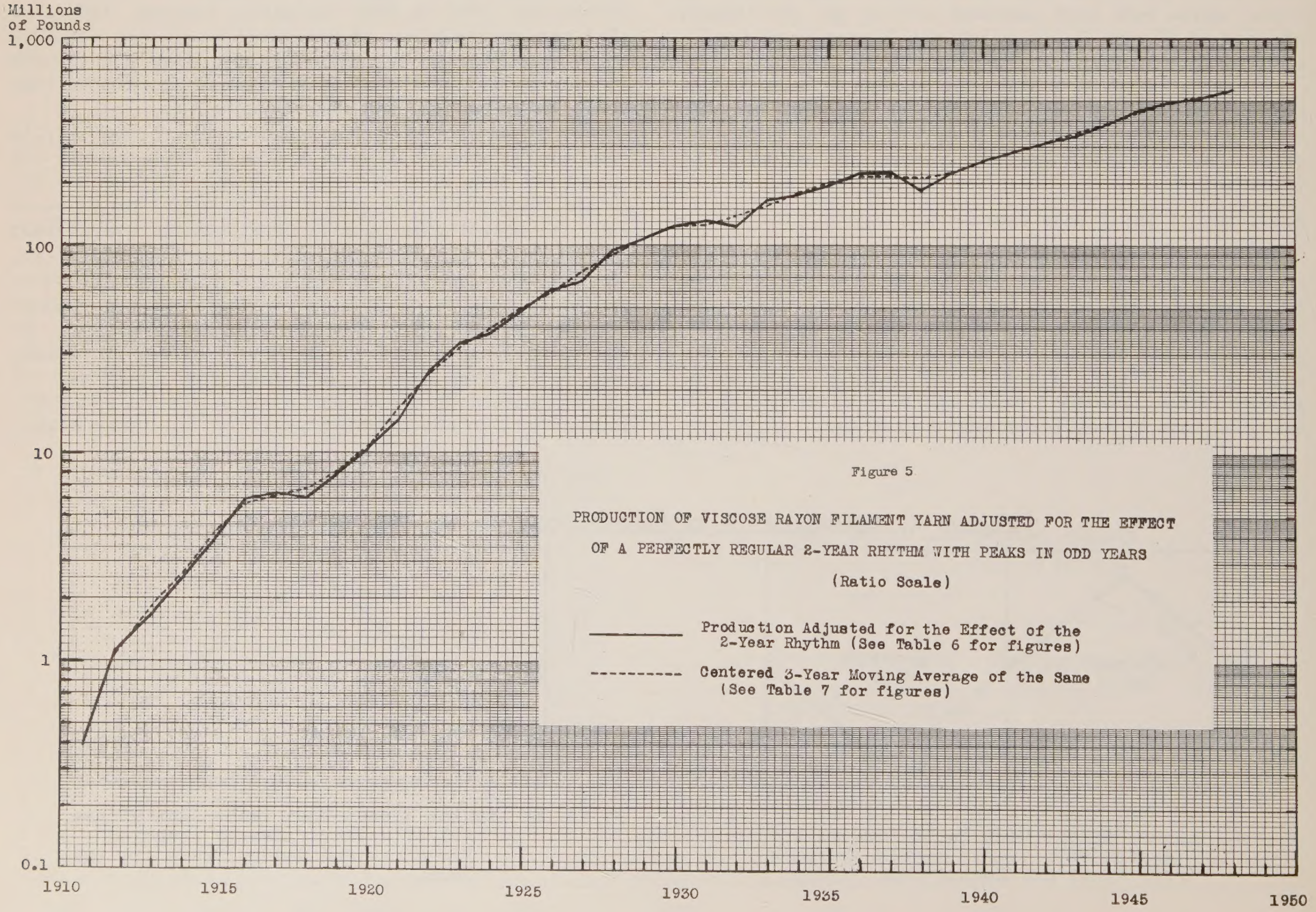


Figure 5

PRODUCTION OF VISCOSE RAYON FILAMENT YARN ADJUSTED FOR THE EFFECT OF A PERFECTLY REGULAR 2-YEAR RHYTHM WITH PEAKS IN ODD YEARS

(Ratio Scale)

at 1/10 of their average 1911-1937 amplitudes. In Part IV will appear the justification for this assumption.

Adjustment for Distortions

There are, however, two slight distortions in this picture. First, a small amount of a 3 1/2-year wave remains in a 3-year moving average. Hence, the deviations from a moving average of this length will not show the full effect of the wave. That is, the true amplitude of the 3 1/2-year wave is slightly greater than that shown in the percentages used. The figures can be adjusted for this distortion by increasing all amplitudes by 13 percent, as shown on Figure 6 by means of a broken line.

The second distortion comes from the fact that we are probably dealing here with a 41- instead of a 42-month (3 1/2-year) rhythm. If this is so, the crests will slip back a month every cycle, two months every seven years. Thus, a crest that came in December in 1911 would come two months earlier, or in October, in 1918, in August in 1925, in June of 1932 and April of 1939. The averages we have constructed will fit well enough for the middle portion of our data, but will be slightly in error toward the ends, and particularly will be out of timing on any projection.

This slippage is not too important in the broad picture, yet if the projections are to be used as a basis for action, the real answer is to do the entire study over, using monthly figures. I recommend that this be done by anyone who plans to spend any money on the basis of this work.

The combined effect of the 2-year rhythm and the 3 1/2-year rhythm from 1911 to 1948 is shown in Table 10 and Chart 8.

Part IV. The 6-Year Rhythm

A skilled eye, even though knowing where to look, could hardly pick out the 6-year rhythm in the raw figures of viscose rayon filament yarn production from 1911 to 1948 plotted in Figure 2. Nevertheless it can be seen in the 2-year moving averages plotted by a broken line (Figure 2).

By proceeding as before, the figures are adjusted for the 2-year wave (Figure 5) and for the 3 1/2-year wave shown in Figure 6. The adjusted figures are given in Table 11 and plotted in Figure 9. The 6-year wave is now easily observable (counting from low to low backward from 1938).

Following earlier procedures, I took a 2-year moving average of a 6-year moving average (Table 12) and plotted the results as a broken line in Figure 9. I then computed the percentages that the adjusted values are of the moving average (Table 13) and plotted the results in Figure 10.

Averaging successive 6-year sections obtains the values of the typical or average pre-war 6-year wave as shown in Table 14. It is shown to have an over-all amplitude of 24 percent. These values are fitted or idealized and plotted as a broken line in Figure 10. A wave for the war and post-war years is added (arbitrarily) at 1/6 the value of the regular 1911-1939 6-year wave. Justification for this assumption will also appear in the parts which follow.

The combined effect of the 2-year, the 3 1/2-year and the 6-year rhythms from 1911 to 1948 is shown in Table 15 and plotted on Figure 11.

Six-Year Rhythm Well Established

The 2-year rhythm and the 41-month rhythm are so well-known and have been described so fully in print by various authors* that I have not taken space to discuss them. The 6-year rhythm is even better established, but not so much has been printed about it.

It has been found to be present for as far back as there are figures in cotton prices (218 years), sunspots with alternate cycles reversed (198 years), automobile production (55 years), orders received by General Electric Company (55 years), and in dozens of other series of natural science and business figures, one of them extending over as long a period as 1,200 years (tree rings on the average in each 181 years).

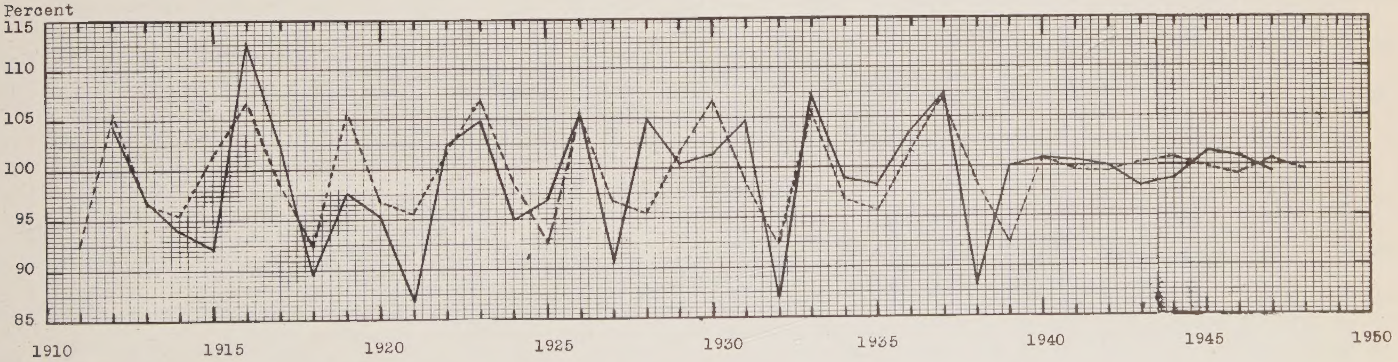


Figure 6

THE 3-1/2-YEAR RHYTHM IN THE PRODUCTION OF VISCOSE RAYON FILAMENT YARN

———— Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year Wave, Are of the Centered 3-Year Moving Average of the Same (**See Table 8 for figures**)

---------- Diagrammatic Representation of a Perfectly Regular Rhythm with Peaks at 3-, 4-, 3-, 4-Year Intervals (**See Table 9 for figures**)

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* SEE REFERENCES 2, 3, 6, 7, 8, 9, 10.

Part V. The 2 3/4-Year Rhythm

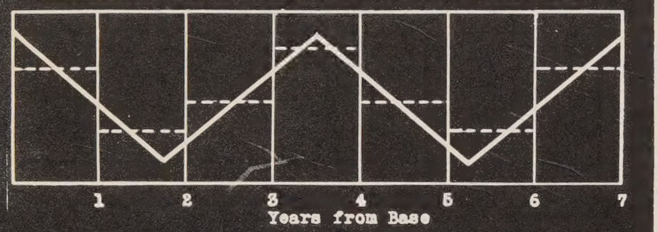
The data of Figure 9 have been adjusted for the idealized 6-year wave, as plotted with a broken line on Figure 10 and made symmetrical by using the 100 percent line as an axis. This is done by using values 12 percent above and 12 percent below trend instead of values 9 percent above and 15 percent below a line of constant value (Table 16). This procedure prevents distorting the level of the trend line. It results in the values that are plotted with a solid line in Figure 12.

The residual shows clearly (as a minor distortion of the smooth underlying growth trend) a fluctuation that is probably the well-known* 33-month, or 2 3/4-year, ("retail") rhythm, more precisely determined in some series to be 32.85 months in length. The peaks relative to them may be noted by counting backwards, 3, 3, 3, 2; 3, 3, 3, 3, 2; 3, 3, and 2 from 1945. Obviously, the existence and length of this fourth rhythm needs to be confirmed by a study of the monthly figures. Yet it may be identified in the annual data.

To reveal it, I computed a 3-year moving average of the data shown in Figure 12 (Table 17 and Figure 12, broken line). Then I computed the percentages that these figures are of the moving averages (Table 18). These percentages are plotted in Figure 13, together with a perfectly regular 3-, 3-, 3-, 2-year pattern.

Figure 7

DIAGRAMMATIC REPRESENTATION OF TWO 3-1/2-YEAR WAVES



The diagram shows that it takes seven years for the wave to come around again to the place of beginning, relative to the calendar year.

Amplitude of the 2 3/4-Year Wave

Assuming that 2 3/4 years is the correct length, I threw these percentages into a 2 3/4-year periodic table as shown in Table 19. The table gives (a) the pre-war and (b) the war and post-war values shown at the bottom of the table. In pre-war years, the over-all amplitude was 8.1 percent but in war and post-war years, 1.1 percent. The percentages so obtained, however, need to be reduced by 8 percent (to adjust for loss in the moving average, which is 9 percent longer than the wave).

Emergence of the Trend

After the values shown in Figure 12 have been ad-

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* See Reference 2. 10.

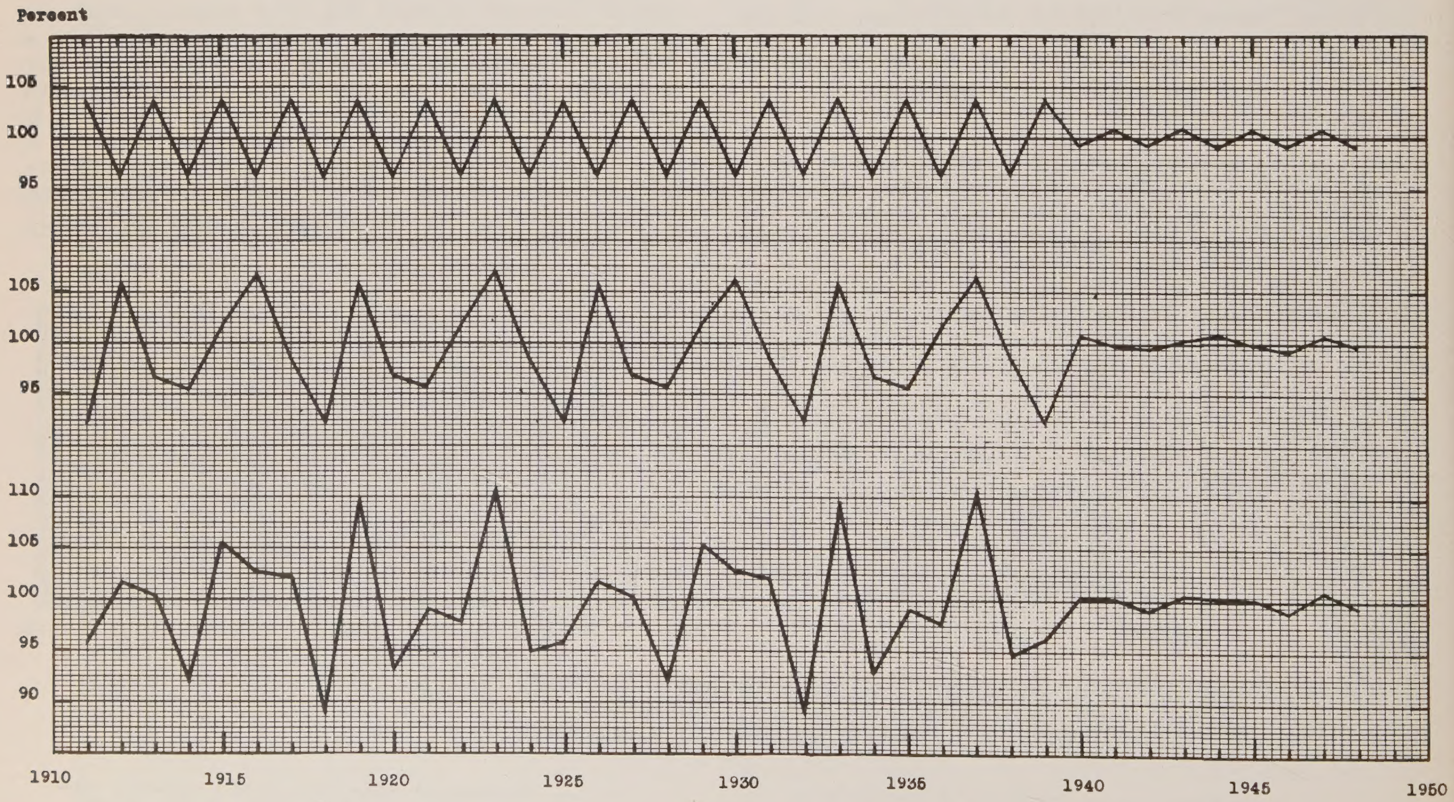


Chart 8

THE 2-YEAR RHYTHM AND THE 3-1/2-YEAR RHYTHM AND THEIR SYNTHESIS

(See Table 10 for figures)

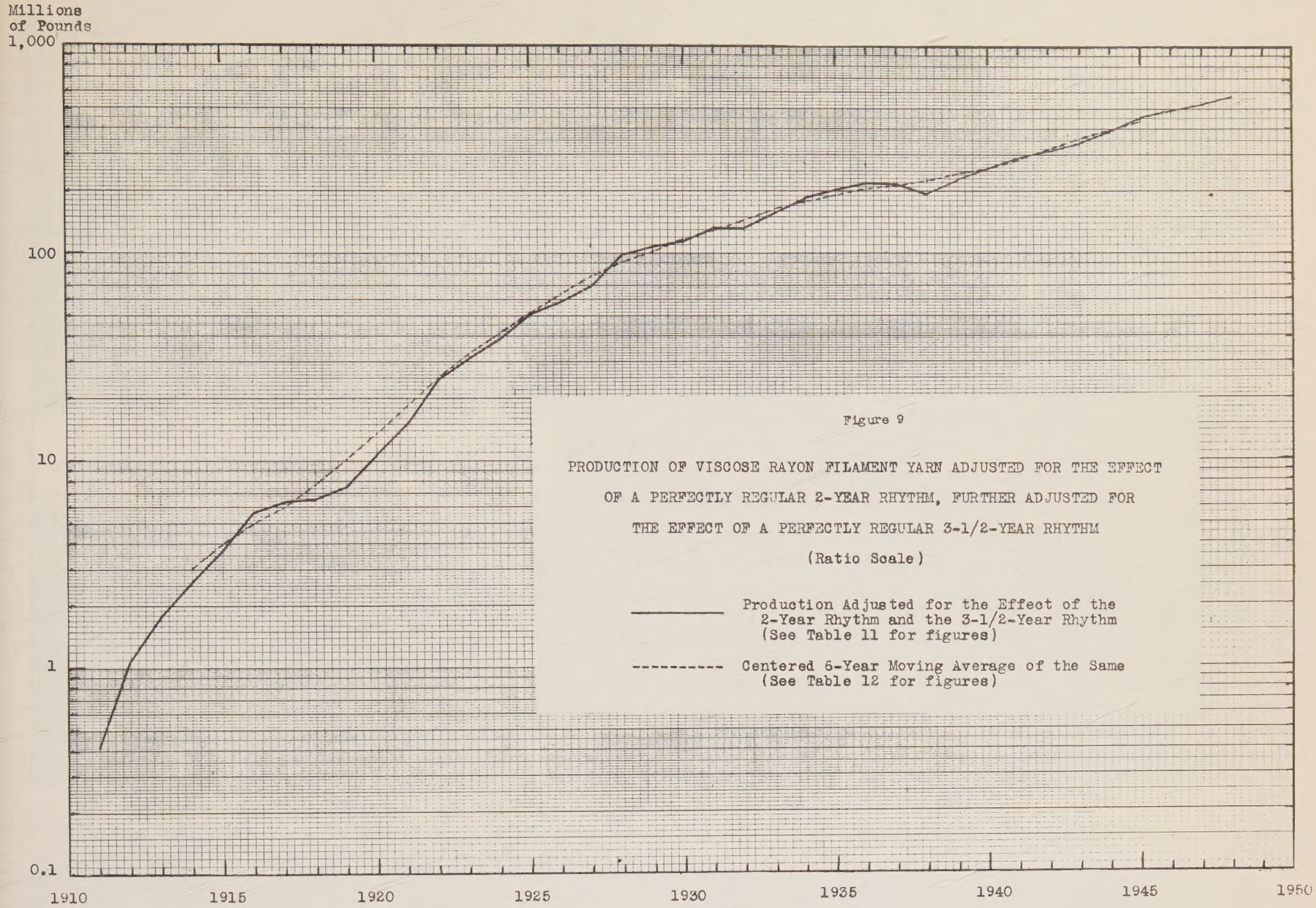


Figure 9

PRODUCTION OF VISCOSE RAYON FILAMENT YARN ADJUSTED FOR THE EFFECT OF A PERFECTLY REGULAR 2-YEAR RHYTHM, FURTHER ADJUSTED FOR THE EFFECT OF A PERFECTLY REGULAR 3-1/2-YEAR RHYTHM

(Ratio Scale)

—————— Production Adjusted for the Effect of the 2-Year Rhythm and the 3-1/2-Year Rhythm (See Table 11 for figures)

---------- Centered 6-Year Moving Average of the Same (See Table 12 for figures)

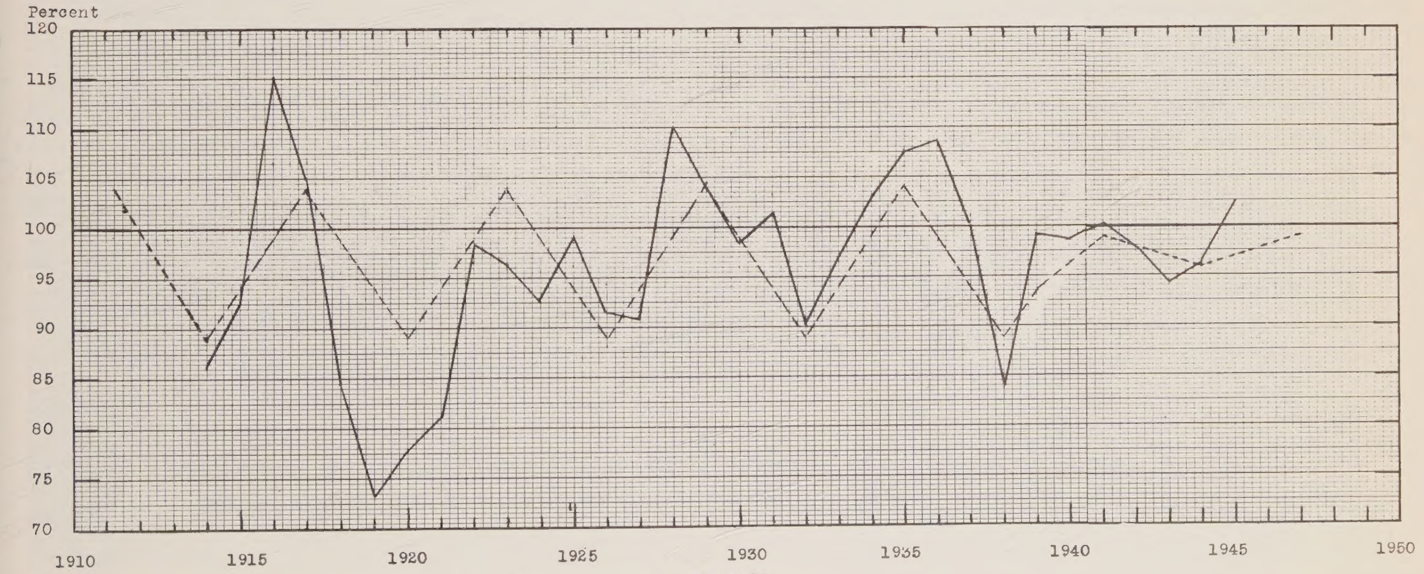


Figure 10

THE 6-YEAR RHYTHM IN THE PRODUCTION OF VISCOSE RAYON FILAMENT YARN

—————— **Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year and 3 1/2-Year Rhythms, Are of the Centered 6-Year Moving Average of the Same** (See Table 13 for figures)

—————— **Diagrammatic Representation of a Perfectly Regular 6-Year Rhythm** (See Table 14 for figures)

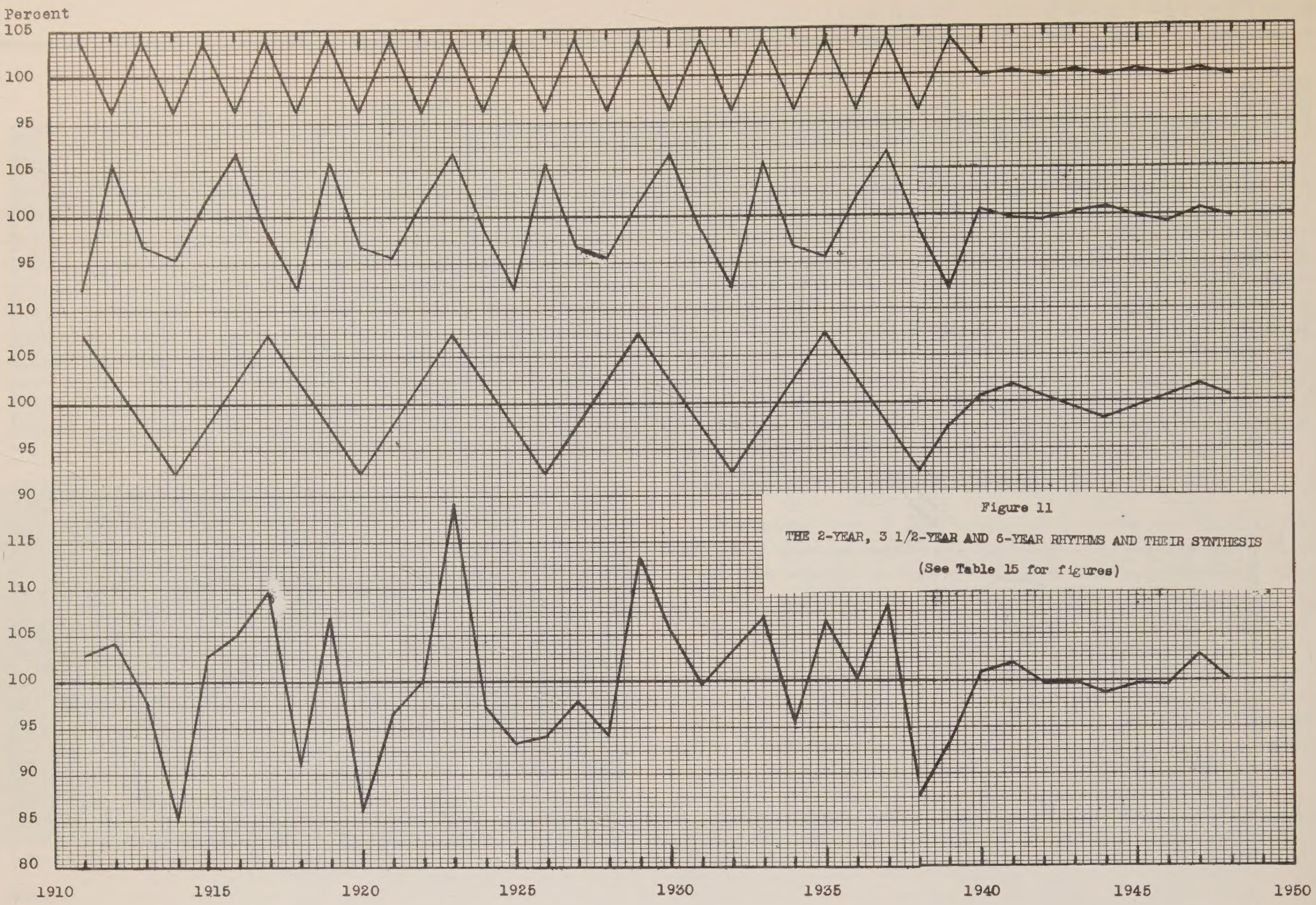


Figure 11

THE 2-YEAR, 3 1/2-YEAR AND 6-YEAR RHYTHMS AND THEIR SYNTHESIS

(See Table 15 for figures)

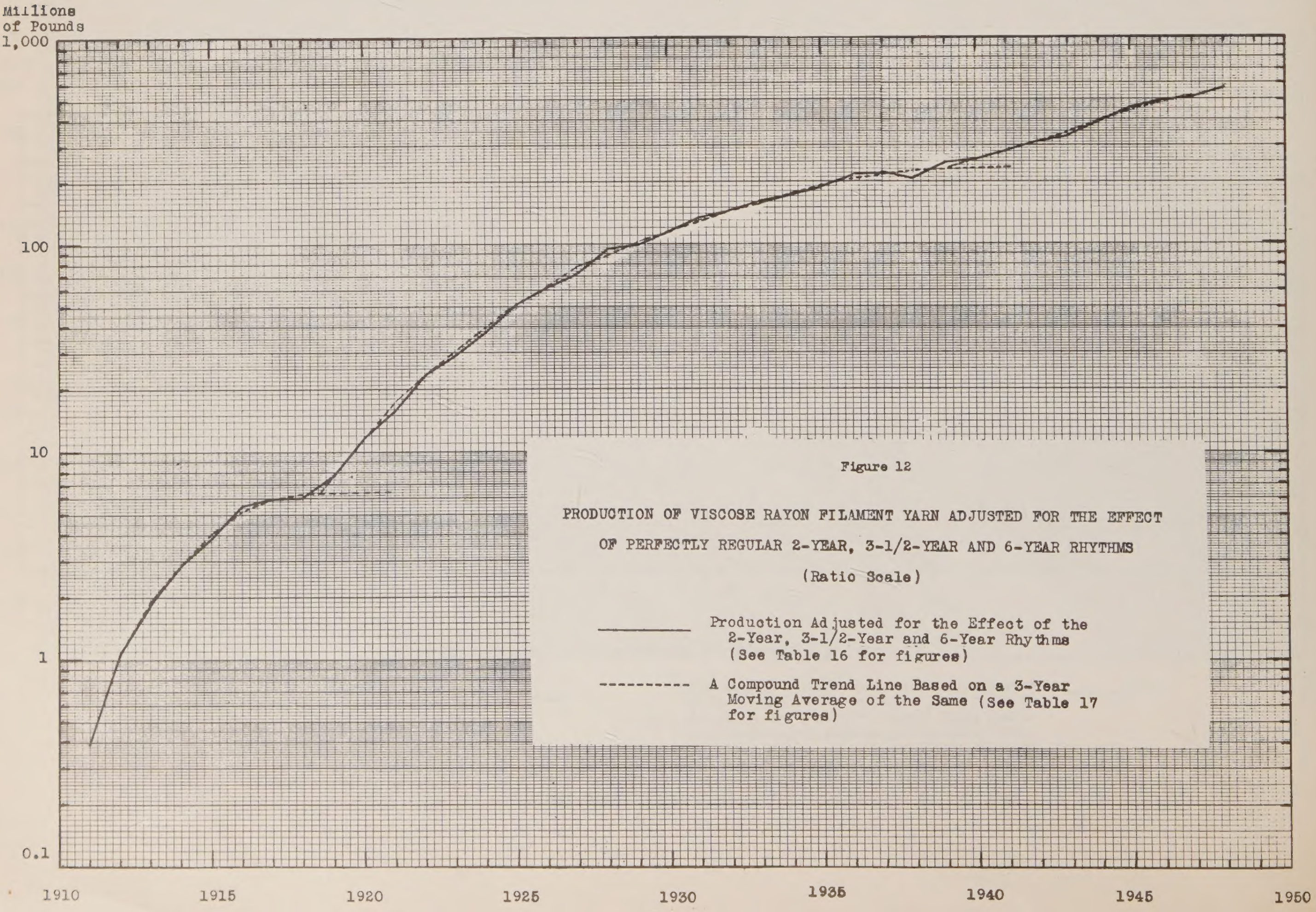


Figure 12

PRODUCTION OF VISCOSE RAYON FILAMENT YARN ADJUSTED FOR THE EFFECT OF PERFECTLY REGULAR 2-YEAR, 3-1/2-YEAR AND 6-YEAR RHYTHMS

(Ratio Scale)

————	Production Adjusted for the Effect of the 2-Year, 3-1/2-Year and 6-Year Rhythms (See Table 16 for figures)
- - - - - -	A Compound Trend Line Based on a 3-Year Moving Average of the Same (See Table 17 for figures)

justed for the values indicated in Table 19, it gives an approximation of the underlying growth trend, together with all the accidental fluctuations that may be present in the series. Smoothing this series graphically to eliminate the accidental fluctuations gives the values recorded in Table 20 and plotted on Figure 14. After adjusting the data for perfectly regular 2-year, 3 1/2-year, 6-year, and 2 3/4-year waves of well-known length, we get as a result an almost perfectly smooth underlying growth trend line. This gives increased confidence in the wave determinations and in the validity of the results. In addition, it would seem to justify the assumption made in regard to war and post-war amplitudes.

Part VI. The Underlying Growth Trend

The underlying growth trend shows what appear to be three distinct periods, or stages. By 1918 all growth of the first stage appears to have ceased, but by 1919 a rebirth occurred that continued into 1939. By this latter year, growth again almost ceased In 1940 there is again evidence of a rebirth that has carried the curve upward through 1948.

Rate of Growth Decreasing

Underlying growth from 1939 to 1945 averaged about 12 percent, but, as nearly as I can estimate it with the use of annual figures, the underlying growth trend from 1945 to 1946 was about 10 percent; from 1946 to 1947, 8 percent; and from 1947 to 1948, 6 percent. The important thing is that the drastic falling-off in rate of growth since 1945 is a definite fact that must be taken into account by all who wish to forecast this series.

Part VII. Synthesis

The values of all the waves from 1911 to 1948 are shown in Table 21 and Figure 15. The table and figure also show the product (synthesis) of these four waves. How to combine the four waves is obvious to a statistician, but may not be so readily understood by others, though it is relatively simple. In 1911, for example, the 2-year wave had a force of value of 103.8 percent; that is, it was "responsible" for production of 3.8 percent above trend. In the same year (1911) the other waves had the forces or values indicated as follows:

The 3 1/2-year wave had a value of 92.3 percent.
The 2 3/4-year wave had a value of 104.1 percent.
The 6-year wave had a value of 107.5 percent.

To get the combined effect of the waves, we must multiply 103.8 percent by 92.3 percent, and multiply the product by 104.1 percent, and multiply that product by 107.5 percent. The answer is 107.2 percent, which represents the combined effect of the four waves for the year 1911. In a similar manner, the synthesis has been made for each year. It is plotted as the fifth curve on Figure 15.

Synthesis of Waves with Trend

To synthesize the waves with the trend, I took each value of the underlying growth trend and multiplied it by the combined effect of the 2-, 2 3/4-, 3 1/2-, and 6-year waves as shown in Table 21 and plotted on Figure 15. This may be compared to the original curve with which we started as shown in Figure 16. This shows the extent to which the four perfectly regular and well-known cycles, and also what we have called the "underlying growth trend," collectively explain the growth and fluctuations of the viscose rayon filament yarn industry.

Part VIII. Projection

If the 2-year, 2 3/4-year, 3 1/2-year and 6-year rhythms remain as they seem to have been since 1940, their combined effect from 1949 to 1960 will approximate the figures given in Table 22, Part A, and plotted on Figure 17, Part A. If they resume 1911-1939 strength, however, the expected combined effect will be as shown in Table 22, Part B, and plotted on Figure

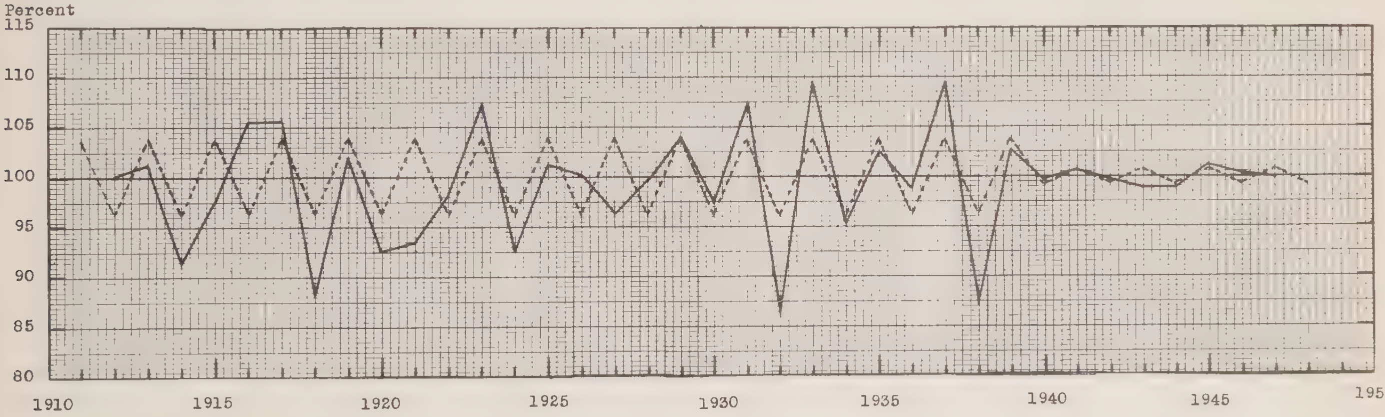


Figure 3

THE 2-YEAR RHYTHM IN THE PRODUCTION OF VISCOSE RAYON FILAMENT YARN

——— Percentages that the Production of Viscose Rayon Filament Yarn Are of the Centered 2-Year Moving Average of the Same (See Table 4 for figures)

------ Diagrammatic Representation of a Perfectly Regular 2-Year Rhythm (See Table 5 for figures)

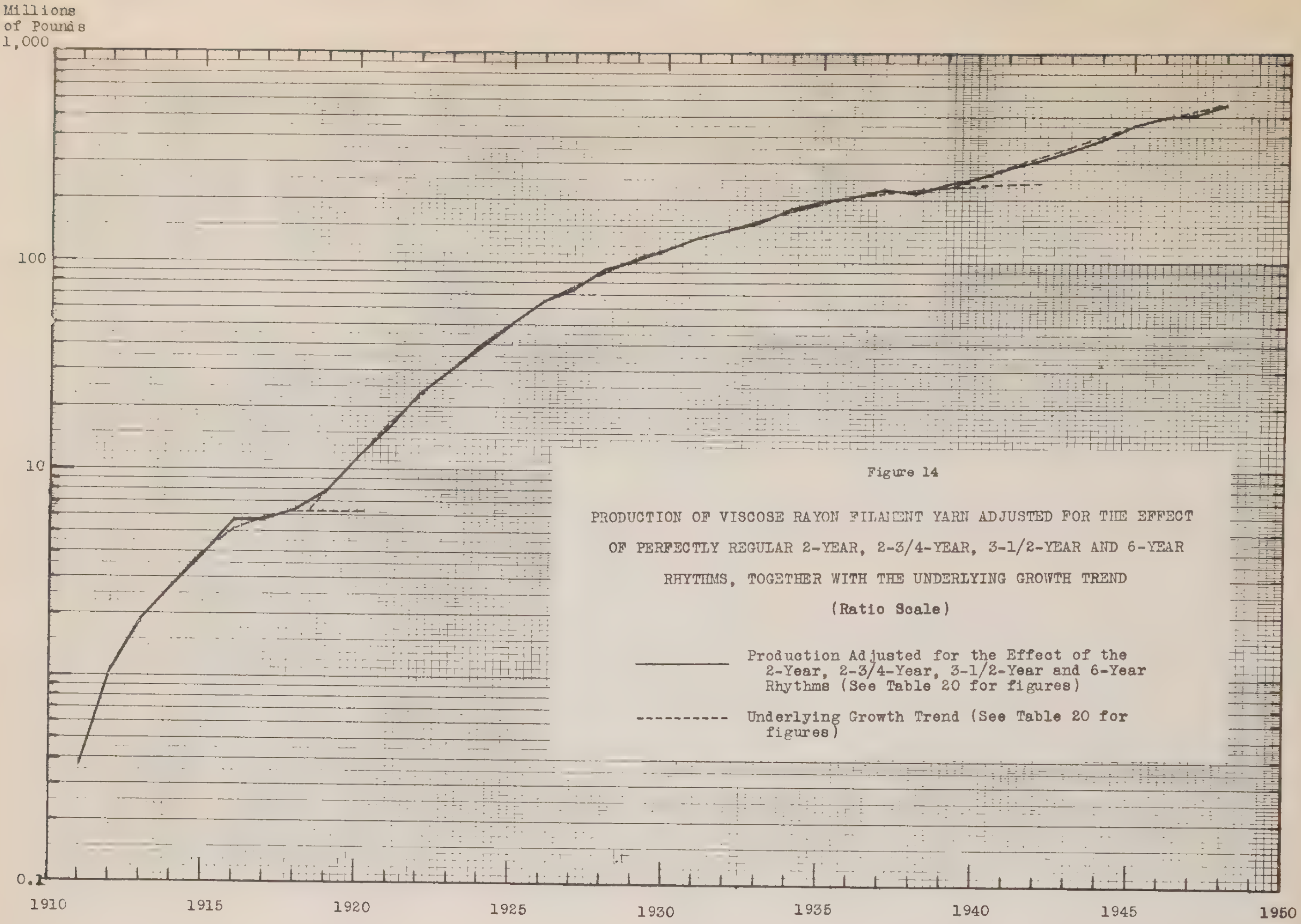


Figure 14

PRODUCTION OF VISCOSE RAYON FILAMENT YARN ADJUSTED FOR THE EFFECT OF PERFECTLY REGULAR 2-YEAR, 2-3/4-YEAR, 3-1/2-YEAR AND 6-YEAR RHYTHMS, TOGETHER WITH THE UNDERLYING GROWTH TREND

(Ratio Scale)

————	Production Adjusted for the Effect of the 2-Year, 2-3/4-Year, 3-1/2-Year and 6-Year Rhythms (See Table 20 for figures)
----------	Underlying Growth Trend (See Table 20 for figures)

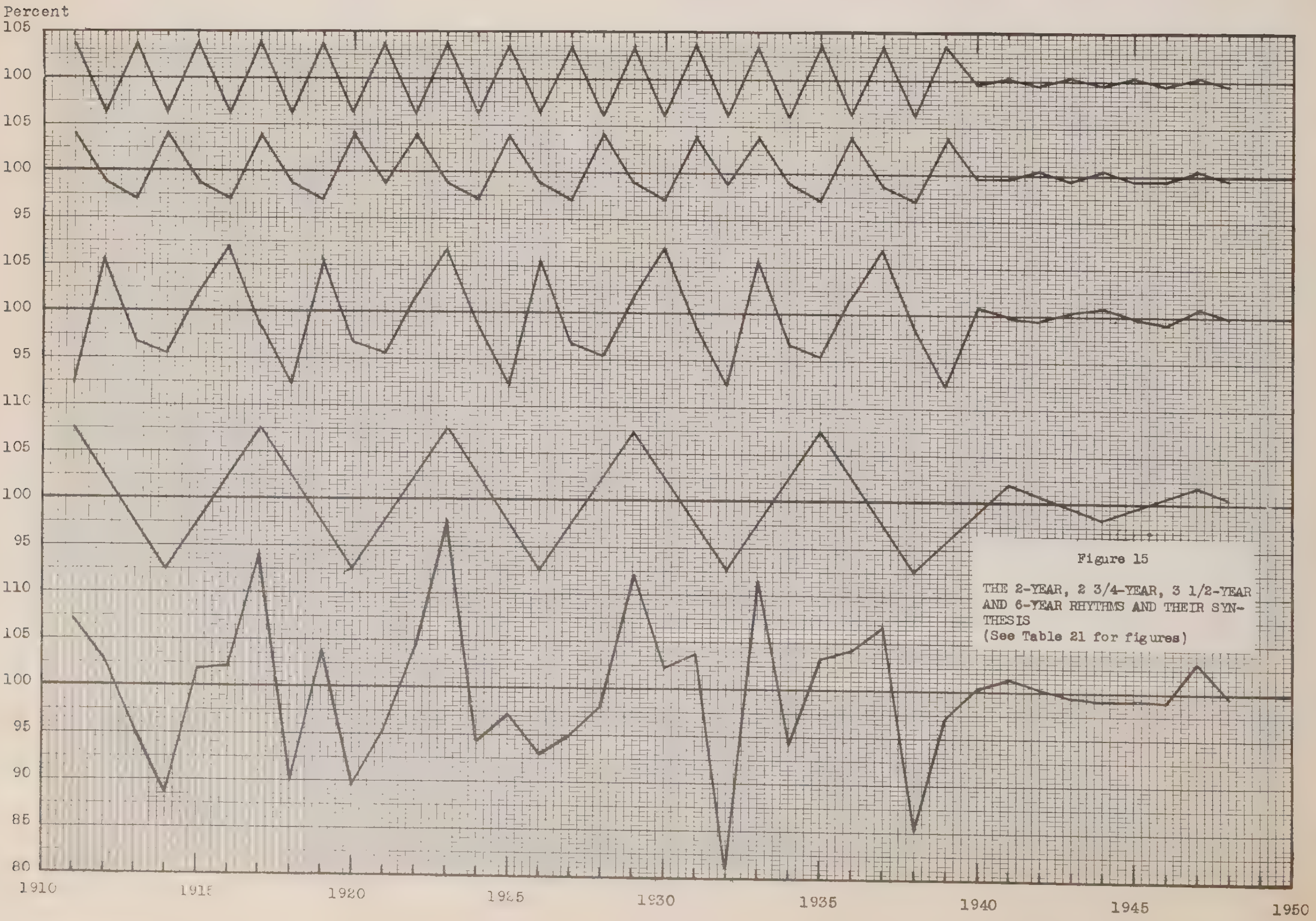


Figure 15

THE 2-YEAR, 2 3/4-YEAR, 3 1/2-YEAR AND 6-YEAR RHYTHMS AND THEIR SYNTHESIS
(See Table 21 for figures)

17, Part B. It is a simple matter of arithmetic to extend either of these syntheses as far into the future as one wishes.

Both of these projections are based on 2-year, 2 3/4-year, and 3 1/2-year lengths instead of the more probable 24 1/4-month, 32.85-month and 41-month lengths. It is not possible, however, to try to be more exact with annual data. Roughly speaking, then, we can expect the underlying growth trend to be influenced as shown in Figure 17 if the rhythms (a) continue at war and post-war strength, or (b) resume at pre-war strength.

Course of the Trend

No one knows what the underlying growth trend will be, but one way to use the above information is to make it throw light, year by year as time unfolds, on what the underlying growth trend is really doing. (It would be much better to use the results of a study of monthly figures to learn each month or each quarter how the underlying situation is changing.) To get figures for the underlying growth trend, we may divide the actual production data for future years when available, by the appropriate figures for the composite effect of the rhythms. On the assumption that the rhythms are continuing, the quotient will be an approximation of the underlying growth trend, subject to any distortions of accidental origin, as well as to the fact that annual data will not give the exact length of the rhythms as well as monthly data.

It is worth repeating at this point that the underlying growth trend, after showing average growth of 12 percent from 1939 to 1945, seems to have slackened to 10 percent from 1945 to 1946, 8 percent from 1946 to 1947, and 6 percent from 1947 to 1948. This very important fact, in addition to all other facts at the disposal of the forecaster, should be taken into account by anyone who has the task of estimating the future production of viscose rayon filament yarn.

Part IX. Recommended Procedures

Anyone who wishes to use this information in a practical way should take the following steps:*

1. Obtain monthly figures, 1911 to date.
2. Determine **exact length, shape, and phase** of the so-called 2-year rhythm (24 1/4 months?) both (a) pre-war and (b) war and post-war.

---

* ALL OF THESE MAY SOUND LIKE A LOT OF WORK, BUT FOREKNOWLEDGE OF FUTURE PROBABILITIES IS NOT AN EASY TASK. OBVIOUSLY, A PROCEDURE THAT WILL THROW LIGHT ON FUTURE EVENTS IS WELL WORTH THE EFFORT.

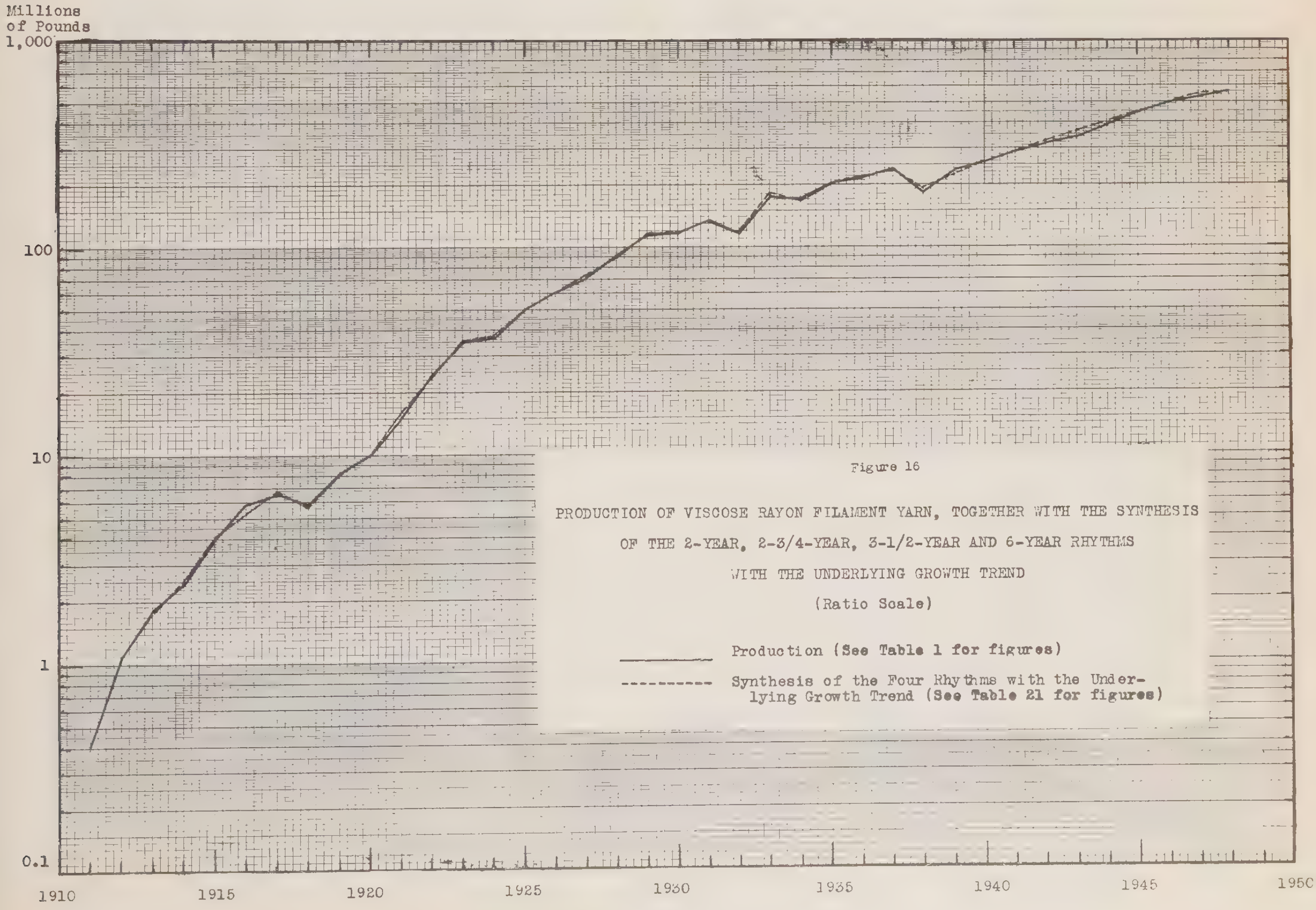


Figure 16

PRODUCTION OF VISCOSE RAYON FILAMENT YARN, TOGETHER WITH THE SYNTHESIS OF THE 2-YEAR, 2-3/4-YEAR, 3-1/2-YEAR AND 6-YEAR RHYTHMS WITH THE UNDERLYING GROWTH TREND

(Ratio Scale)

——— Production (See Table 1 for figures)

---------- Synthesis of the Four Rhythms with the Underlying Growth Trend (See Table 21 for figures)

3. Do the same for what in this paper has been called the 2 3/4-year rhythm (32.85 months?).

4. Do the same for the so-called 3 1/2-year rhythm (41 months?).

5. Do the same for the so-called 6-year rhythm (70.9 months, or 73.3 months, or a combination of the two?).

6. In all of these determinations it will be helpful to work with the percentages that the actual data are of the tentative underlying growth trend, as reported here, converted to a monthly basis.

7. Adjust for all these rhythms.

8. Revise the underlying growth trend to take account of the more accurate wave length, wave shape, and timing determinations.

9. Revise estimates of the recent behavior of the underlying growth trend, and project it into the future taking all known factors into account.

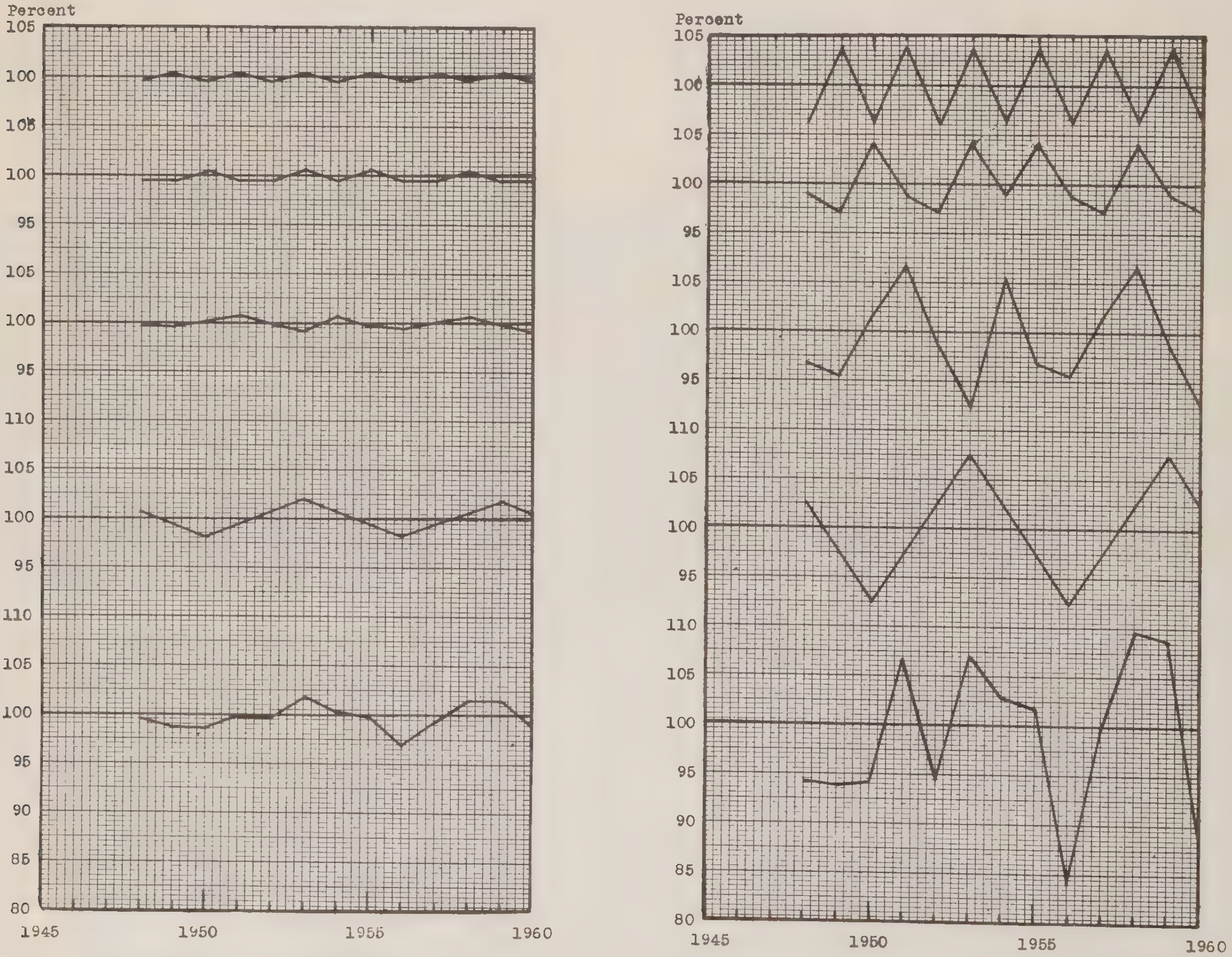
10. In view of the increased importance of rayon tire cord, it would be well to make a study of the rhythms and trend in tire production. I do not know what they are, but I do know that the 6-year rhythm is very important in the factory sales of passenger cars.

11. A study should also be made of the rhythms and trend in the **sales** of viscose rayon filament yarn.

12. Project the combined **monthly** waves into the future on both (a) the war and post-war and (b) the pre-war basis, and "wrap them around" the projected growth trend.

13. Each quarter investigate to see the extent to which the pre-war waves have come back, and to see any changes creeping into the underlying growth situation.

14. Revise the forecasts periodically in the light of all these factors.



A. Projection Based on 1940-1948 Amplitudes

B. Projection Based on 1911-1939 Amplitudes

Figure 17

THE 2-YEAR, 2-3/4-YEAR, 3-1/2-YEAR AND 6-YEAR RHYTHMS
AND THEIR SYNTHESIS PROJECTED TO 1960
(See Table 22 for figures)

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T A B L E S

Table 1

Production of Viscose* Rayon Filament Yarn in the United States, 1911-1948**
(See Chart 1, and Chart 2, solid line)

Year	Production (Millions of Pounds)	Year	Production (Millions of Pounds)
1911	0.4	1931	135.2
1912	1.1	1932	116.4
1913	1.8	1933	172.4
1914	2.4	1934	170.3
1915	3.9	1935	202.0
1916	5.8	1936	214.9
1917	6.5	1937	238.2
1918	5.8	1938	181.5
1919	8.2	1939	231.3
1920	10.0	1940	257.1
1921	14.9	1941	287.5
1922	24.0	1942	310.5
1923	34.8	1943	338.5
1924	36.2	1944	383.5
1925	49.4	1945	448.8
1926	60.1	1946	491.2
1927	70.4	1947	525.2
1928	91.2	1948	562.3
1929	113.0		
1930	117.5		

* Wherever the word "viscose" appears in this report it is understood to include nitrocellulose process rayon yarn until its production was discontinued in 1934, and also to include the production of cuprammonium filament yarn from its first production to date.

** Source: Rayon Organon. February, 1949, page 20.

Table 2

The Percentage that Each Year's Production of Viscose Rayon Filament Yarn Is of Production for the Previous Year

Year	Percent
1911	----
1912	275 0
1913	163.6
1914	133.3
1915	162.5
1916	148.7
1917	112.1
1918	89.2
1919	141.4
1920	122.0
1921	149.0
1922	161.1
1923	145.0
1924	104.0
1925	136.5
1926	121.7
1927	117.1
1928	129.5
1929	123.9
1930	104.0
1931	115.1
1932	86.1
1933	148.1
1934	98.8
1935	118.6
1936	106.4
1937	110.8
1938	76.2
1939	127.4
1940	111.2
1941	111.8
1942	108.0
1943	109.0
1944	113.3
1945	117.0
1946	109.4
1947	106.9
1948	107.1

Centered 2-Year Moving Average of the Production of Viscose Rayon Filament Yarn
(See Chart 2, broken line)

Year	Moving Average	Year	Moving Average
		1931	126.08
1912	1.10	1932	135.10
1913	1.78	1933	157.88
1914	2.63	1934	178.75
1915	4.00	1935	197.30
1916	5.50	1936	217.50
1917	6.15	1937	218.20
1918	6.58	1938	208.13
1919	8.05	1939	225.30
1920	10.78	1940	258.25
1921	15.95	1941	285.65
1922	24.43	1942	311.75
1923	32.45	1943	342.75
1924	39.15	1944	388.58
1925	48.78	1945	443.08
1926	60.00	1946	489.10
1927	73.02	1947	525.98
1928	91.45		
1929	108.68		
1930	120.80		

For the benefit of those who are not statisticians, but who may wish to know, this is how a centered, or 2-year, moving average of a 2-year moving average is computed: Average the first and second figures of the original data. Average the second and third figures, then average the third and fourth, the fourth and fifth, and so forth, through the entire series. This gives the first 2-year moving average. Then, using these averages as data, do it all over again. This provides a 2-year moving average of a 2-year moving average. The second series of calculations is made because it is not possible to center exactly a moving average with an even number of terms. Plot the first figure of the results in the 1912 position, and so on to 1947. There will be one figure missing at each end. That is why the broken line in Figure 2 runs only from 1912 to 1947, inclusive, and cannot continue to 1948 until the figures for 1949 are available to average in with the 1948 figures to extend the moving average to 1948.

Table 4

Percentages that the Production of Viscose Rayon Filament Yarn Are of the Centered 2-Year Moving Average of the Same

(See Chart 3, solid line)

Year	Percent
1911	---
1912	100.0
1913	101.1
1914	91.3
1915	97.5
1916	105.5
1917	105.7
1918	88.1
1919	101.9
1920	92.8
1921	93.4
1922	98.2
1923	107.2
1924	92.5
1925	101.3
1926	100.2
1927	96.4
1928	99.7
1929	104.0
1930	97.3
1931	107.2
1932	86.2
1933	109.2
1934	95.3
1935	102.4
1936	98.8
1937	109.2
1938	87.2
1939	102.7
1940	99.6
1941	100.6
1942	99.6
1943	98.8
1944	98.7
1945	101.3
1946	100.4
1947	99.9
1948	---

Table 5

Two-Year Periodic Table of the Percentages that the Production of Viscose Rayon Filament Yarn Are of the Centered 2-Year Moving Average of the Same

(See Chart 3, broken line)

Part A. The Years 1912 through 1939

Base Year	Years after Base Year 1	2
1911	100.0	101.1
1913	91.3	97.5
1915	105.5	105.7
1917	88.1	101.9
1919	92.8	93.4
1921	98.2	107.2
1923	92.5	101.3
1925	100.2	96.4
1927	99.7	104.0
1929	97.3	107.2
1931	86.2	109.2
1933	95.3	102.4
1935	98.8	109.2
1937	87.2	102.7
Sum	1333.1	1439.2
Average	95.2	102.8

Over-all Amplitude Equals 7.6

Part B. The Years 1940 through 1947

Base Year	Years after Base Year 1	2
1939	99.6	100.6
1941	99.6	98.8
1943	98.7	101.3
1945	100.4	99.9
Sum	398.3	400.6
Average	99.6	100.2

Over-all Amplitude Equals 0.6

Table 6

Production of Viscose Rayon Filament Yarn Adjusted for the Effect of a Perfectly Regular 2-Year Rhythm with Peaks in Odd Years

(See Chart 5, solid line)

Over-all amplitude, 1911-1939, equals 7.6 per cent.
Over-all amplitude, 1940-1948, equals 0.6 per cent.

Year	(A) Production (Millions of Pounds	(B) The 2-Year Rhythm (Based on Table 5)	(C) Production Adjusted for 2-Year Rhythm (Millions of Pounds) (A ÷ B)
1911	0.4	103.8 %	0.39
1912	1.1	96.2	1.14
1913	1.8	103.8	1.73
1914	2.4	96.2	2.50
1915	3.9	103.8	3.76
1916	5.8	96.2	6.03
1917	6.5	103.8	6.26
1918	5.8	96.2	6.0
1919	8.2	103.8	7.9
1920	10.0	96.2	10.4
1921	14.9	103.8	14.4
1922	24.0	96.2	24.9
1923	34.8	103.8	33.5
1924	36.2	96.2	37.6
1925	49.4	103.8	47.6
1926	60.1	96.2	62.5
1927	70.4	103.8	67.8
1928	91.2	96.2	94.8
1929	113.0	103.8	108.9
1930	117.5	96.2	122.1
1931	135.2	103.8	130.3
1932	116.4	96.2	121.0
1933	172.4	103.8	166.1
1934	170.3	96.2	177.0
1935	202.0	103.8	194.6
1936	214.9	96.2	223.4
1937	238.2	103.8	229.5
1938	181.5	96.2	188.7
1939	231.3	103.8	222.8
1940	257.1	99.7	257.9
1941	287.5	100.3	286.6
1942	310.5	99.7	311.4
1943	338.5	100.3	337.5
1944	383.5	99.7	384.7
1945	448.8	100.3	447.5
1946	491.2	99.7	492.7
1947	525.2	100.3	523.6
1948	562.3	99.7	564.0

Column B is 100 per cent plus-or-minus 1/2 the over-all amplitude derived in Table 5.

Table 7

Centered 3-Year Moving Average of the Production of Viscose Rayon Filament Yarn Adjusted for the Effect

Year	Production Adjusted for 2-Year Rhythm (from Table 6, Col. C)	3-Year Moving Average of Adjusted Production
1911	0.39	---
1912	1.14	1.09
1913	1.73	1.79
1914	2.50	2.66
1915	3.76	4.10
1916	6.03	5.35
1917	6.26	6.10
1918	6.0	6.7
1919	7.9	8.1
1920	10.4	10.9
1921	14.4	16.6
1922	24.9	24.3
1923	33.5	32.0
1924	37.6	39.6
1925	47.6	49.2
1926	62.5	59.3
1927	67.8	75.0
1928	94.8	90.5
1929	108.9	108.6
1930	122.1	120.4
1931	130.3	124.5
1932	121.0	139.1
1933	166.1	154.7
1934	177.0	179.2
1935	194.6	198.3
1936	223.4	215.8
1937	229.5	213.9
1938	188.7	213.7
1939	222.8	223.1
1940	257.9	255.8
1941	286.6	285.3
1942	311.4	311.8
1943	337.5	344.5
1944	384.7	389.9
1945	447.5	441.6
1946	492.7	487.9
1947	523.6	526.8
1948	564.0	---

(Continued in next column)

Table 8

Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year Wave, Are of the Centered 3-Year Moving Average of the Same

(See Chart 6, solid line)

Year	Percent
1911	*
1912	104.5
1913	96.7
1914	94.0
1915	91.7
1916	112.7
1917	102.6
1918	89.6
1919	97.5
1920	95.4
1921	86.7
1922	102.5
1923	104.7
1924	94.9
1925	96.7
1926	105.4
1927	90.4
1928	104.8
1929	100.3
1930	101.4
1931	104.7
1932	87.0
1933	107.4
1934	98.8
1935	98.1
1936	103.5
1937	107.3
1938	88.3
1939	99.9
1940	100.8
1941	100.5
1942	99.9
1943	98.0
1944	98.7
1945	101.3
1946	101.0
1947	99.4
1948	*

* As the moving average runs only from 1912 to 1947, there are no percentages for 1911 and 1948.

Table 9

Seven-Year Periodic Table of the Percentages of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year Wave, Are of the Centered 3-Year Moving Average of the Same (See Chart 6, broken line)

Part A. The Years 1912 through 1939

Base Year	Years After Base Year 1	2	3	4	5	6	7
1911	104.5	96.7	94.0	91.7	112.7	102.6	89.6
1918	97.5	95.4	86.7	102.5	104.7	94.9	96.7
1925	105.4	90.4	104.8	100.3	101.4	104.7	87.0
1932	107.4	98.8	98.1	103.5	107.3	88.3	99.9
Sum	414.8	381.3	383.6	398.0	426.1	390.5	373.2
Average (Mean)	103.7	95.3	95.9	99.5	106.5	97.6	93.3
Median	105.0	97.1	96.0	101.4	106.0	98.7	93.2
Adjustment**	105.7	96.7	95.5	101.6	106.8	98.5	92.3

Part B. The Years 1940 through 1947

Base Year	Years After Base Year 1	2	3	4	5	6	7
1939	100.8	100.5	99.9	98.0	98.7	101.3	101.0
1946	99.4						
Average (Mean)	100.1	100.5	99.9	98.0	98.7	101.3	101.0
Adjustment***	100.6	99.7	99.5	100.2	100.7	99.9	99.2

* Deviations from 100% are increased 13% because some of a 3 1/2-year cycle remains in a 3-year moving average. A 3 1/2-year cycle in the deviations from such a moving average is thus smaller than it is in the actual figures. The wave as it appears in the deviations must therefore be given greater amplitude before it is used as a correction factor.

** The 3 1/2-year wave from 1940 through 1947 is assumed to be present at 1/10 of the average 1911-1937 amplitude. See text, bottom of page 6.

Addendum: After this report was finished it was discovered that the median in the second column above should have been recorded as 96.1 instead of 97.1. Consequently the adjusted value should have been 95.6 instead of 96.7. This error introduces a slight distortion in the remaining work, but in view of the very much larger distortion already in the work due to the use of annual instead of monthly figures, it does not seem necessary to recompute the remaining tables.

Table 10

Synthesis of the 2-Year Rhythm and the 3 1/2-Year Rhythm of the Given Amplitudes (See Chart 9)

Year	(A) 2-Year Wave	(B) 3-1/2-Year Wave	(C) Synthesis (A x B)
1911	103.8	92.3	95.8
1912	96.2	105.7	101.7
1913	103.8	96.7	100.4
1914	96.2	95.5	91.9
1915	103.8	101.6	105.5
1916	96.2	106.8	102.7
1917	103.8	98.5	102.2
1918	96.2	92.3	88.8
1919	103.8	105.7	109.7
1920	96.2	96.7	93.0
1921	103.8	95.5	99.1
1922	96.2	101.6	97.7
1923	103.8	106.8	110.9
1924	96.2	98.5	94.8
1925	103.8	92.3	95.8
1926	96.2	105.7	101.7
1927	103.8	96.7	100.4
1928	96.2	95.5	91.9
1929	103.8	101.6	105.5
1930	96.2	106.8	102.7
1931	103.8	98.5	102.2
1932	96.2	92.3	88.8
1933	103.8	105.7	109.7
1934	96.2	96.7	93.0
1935	103.8	95.5	99.1
1936	96.2	101.6	97.7
1937	103.8	106.8	110.9
1938	96.2	98.5	94.8
1939	103.8	92.3	95.8
1940	99.7	100.6	100.3
1941	100.3	99.7	100.0
1942	99.7	99.5	99.2
1943	100.3	100.2	100.5
1944	99.7	100.7	100.4
1945	100.3	99.9	100.2
1946	99.7	99.2	98.9
1947	100.3	100.6	100.9
1948	99.7	99.7	99.4

Table 11

Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of a Regular 2-Year Rhythm, Further Adjusted for the Effect of a Regular 3 1/2-Year Rhythm

Year	(A) Production Adjusted for 2-Year Rhythm (Millions of Pounds)	(B) The 3-1/2-Year Rhythm	(C) Production Adjusted for both 2-Year and 3-1/2-Year Rhythms (Millions of Pounds) (A ÷ B)
1911	0.39	92.3	0.42
1912	1.14	105.7	1.08
1913	1.73	96.7	1.79
1914	2.50	95.5	2.62
1915	3.76	101.6	3.70
1916	6.03	106.8	5.65
1917	6.26	98.5	6.36
1918	6.0	92.3	6.5
1919	7.9	105.7	7.5
1920	10.4	96.7	10.8
1921	14.4	95.5	15.1
1922	24.9	101.6	24.5
1923	33.5	106.8	31.4
1924	37.6	98.5	38.2
1925	47.6	92.3	51.6
1926	62.5	105.7	59.1
1927	67.8	96.7	70.1
1928	94.8	95.5	99.3
1929	108.9	101.6	107.2
1930	122.1	106.8	114.3
1931	130.3	98.5	132.3
1932	121.0	92.3	131.1
1933	166.1	105.7	157.1
1934	177.0	96.7	183.0
1935	194.6	95.5	203.8
1936	223.4	101.6	219.9
1937	229.5	106.8	214.9
1938	188.7	98.5	191.6
1939	222.8	92.3	241.4
1940	257.9	100.6	256.4
1941	286.6	99.7	287.5
1942	311.4	99.5	313.0
1943	337.5	100.2	336.8
1944	384.7	100.7	382.0
1945	447.5	99.9	447.9
1946	492.7	99.2	496.7
1947	523.6	100.6	520.5
1948	564.0	99.7	565.7

Column B is derived from Table 9.

Table 12

Centered, or 2-Year, Moving Average of a 6-Year Moving Average of the Production of Viscose Rayon Filament Yarn Adjusted for the Effect of the 2- and 3 1/2-year rhythms

Year	(A) Production Adjusted for both 2-Year and 3-1/2-Year Rhythms (Millions of Pounds) (from Table 11)	(B) Centered, or 2-Year, Moving Average of a 6-Year Moving Average of Column (A)
1911	0.42	---
1912	1.08	---
1913	1.79	---
1914	2.62	3.04
1915	3.70	3.99
1916	5.65	4.91
1917	6.36	6.07
1918	6.5	7.70
1919	7.5	10.23
1920	10.8	13.88
1921	15.1	18.6
1922	24.5	24.9
1923	31.4	32.6
1924	38.2	41.2
1925	51.6	52.1
1926	59.1	64.6
1927	70.1	77.3
1928	99.3	90.3
1929	107.2	103.1
1930	114.3	116.3
1931	132.3	130.5
1932	131.1	145.6
1933	157.1	162.4
1934	183.0	178.1
1935	203.8	190.0
1936	219.9	202.1
1937	214.9	215.2
1938	191.6	228.3
1939	241.4	243.0
1940	256.4	261.0
1941	287.5	287.0
1942	313.0	320.1
1943	336.8	357.3
1944	382.0	396.7
1945	447.9	437.2
1946	496.7	---
1947	520.5	---
1948	565.7	---

See footnote to Table 3 for method of calculating a centered moving average based on an even number of terms.

Table 13

Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year and 3-1/2-Year Rhythms, Are of the Centered 6-Year Moving Average of the Same (See Chart 10, solid line)

Year	Percent
1911	---
1912	---
1913	---
1914	86.2
1915	92.7
1916	115.1
1917	104.8
1918	84.4
1919	73.3
1920	77.8
1921	81.2
1922	98.4
1923	96.3
1924	92.7
1925	99.0

(Continued on next page)

Table 13 (Continued)

1926	91.5
1927	90.7
1928	110.0
1929	104.0
1930	98.3
1931	101.4
1932	90.0
1933	96.7
1934	102.8
1935	107.3
1936	108.8
1937	99.9
1938	83.9
1939	99.3
1940	98.2
1941	100.2
1942	97.8
1943	94.3
1944	96.3
1945	102.4
1946	---
1947	---
1948	---

Table 14

Six-Year Periodic Table of the Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year and 3 1/2-Year Waves, Are of the Centered 6-Year Moving Average of the Same
(See Chart 10, broken line)

Base Year	Years After Base Year 1	2	3	4	5	6
1913	86.2	92.7	115.1	104.8	84.4	73.3
1919	77.8	81.2	98.4	96.3	92.7	99.0
1925	91.5	90.7	110.0	104.0	98.3	101.4
1931	90.0	96.7	102.8	107.3	108.8	99.9
1937	83.9	99.3	98.2	100.2	97.7	94.3
1941	96.4	103.0				
Median*	88.1	94.7	102.8	104.0	97.5	99.0
Idealization** 1911-1959 to base 1913	92.5	97.5	102.5	107.5	102.5	97.5
Idealization*** 1940-1948 to base 1937	98.2	99.4	100.6	101.8	100.6	99.4

* The average of the two middle value figures in columns 1 and 2; of the two middle values in columns 3, 4, 5, and 6.

** The median raised to be symmetrical around the 100 per cent axis, in shape as well as position.

*** The 6-year wave from 1940 through 1948 is, in this line, assumed to be present at 1/6 of the average 1911-1937 amplitude. See text, page 8.

Table 15

Synthesis of the 2-Year 3-1/2-Year and 6-Year Rhythms of the Given Amplitudes
(See Chart 11)

Year	(A) Synthesis of 2-Year and 3-1/2-Year Waves (from Table 10)	(B) 6-Year Wave	(C) Composite of All 3 Waves (A x B)
1911	95.8	107.5	103.0
1912	101.7	102.5	104.2
1913	100.4	97.5	97.9
1914	91.9	92.5	85.0
1915	105.5	97.5	102.9
1916	102.7	102.5	105.3
1917	102.2	107.5	109.9
1918	88.8	102.5	91.0
1919	109.7	97.5	107.0
1920	93.0	92.5	86.0
1921	99.1	97.5	96.6
1922	97.7	102.5	100.1
1923	110.9	107.5	119.2
1924	94.8	102.5	97.2
1925	95.8	97.5	93.4
1926	101.7	92.5	94.1
1927	100.4	97.5	97.9
1928	91.9	102.5	94.2
1929	105.5	107.5	113.4
1930	102.7	102.5	105.3
1931	102.2	97.5	99.6
1932	88.8	92.5	82.1
1933	109.7	97.5	107.0
1934	93.0	102.5	95.3
1935	99.1	107.5	106.5
1936	97.7	102.5	100.1
1937	110.9	97.5	108.1
1938	94.8	92.5	87.7
1939	95.8	97.5	93.4
1940	100.3	100.6	100.9
1941	100.0	101.8	101.8
1942	99.2	100.6	99.8
1943	100.5	99.4	99.9
1944	100.4	98.2	98.6
1945	100.2	99.4	99.6
1946	98.9	100.6	99.5
1947	100.9	101.8	102.7
1948	99.4	100.6	100.0

Column B based on Table 14.

Table 16

Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of Perfectly Regular 2-Year, 3-1/2-Year and 6-Year Rhythms
(See Chart 12, solid line)

Year	(A) Production Adjusted for both 2-Year and 3-1/2-Year Rhythms (Millions of Pounds) (from Table 11)	(B) The 6-Year Rhythm	(C) Production Adjusted for the 2-Year, 3-1/2-Year and 6-Year Rhythms (Millions of Pounds) (A ÷ B)
1911	0.42	107.5	0.39
1912	1.08	102.5	1.05
1913	1.79	97.5	1.84
1914	2.62	92.5	2.83
1915	3.70	97.5	3.79
1916	5.65	102.5	5.51
1917	6.36	107.5	5.92
1918	6.5	102.5	6.3
1919	7.5	97.5	7.7
1920	10.8	92.5	11.7
1921	15.1	97.5	15.5
1922	24.5	102.5	23.9
1923	31.4	107.5	29.2
1924	38.2	102.5	37.3
1925	51.6	97.5	52.9
1926	59.1	92.5	63.9
1927	70.1	97.5	71.9
1928	99.3	102.5	96.9
1929	107.2	107.5	99.7
1930	114.3	102.5	111.5
1931	132.3	97.5	135.7
1932	131.1	92.5	141.7
1933	157.1	97.5	161.1
1934	183.0	102.5	178.5
1935	203.8	107.5	189.6
1936	219.9	102.5	214.5
1937	214.9	97.5	220.4
1938	191.6	92.5	207.1
1939	241.4	97.5	247.6
1940	256.4	100.6	254.9
1941	287.5	101.8	282.4
1942	313.0	100.6	311.1
1943	336.8	99.4	338.8
1944	382.0	98.2	389.0
1945	447.9	99.4	450.6
1946	496.7	100.6	493.7
1947	520.5	101.8	511.3
1948	565.7	100.6	562.3

Column B based on Table 14.

Table 17

Three-Year Moving Average of the Production of Viscose Rayon Filament Yarn Adjusted for the Effect of the 2-Year, 3 1/2-Year and 6-Year Waves

(See Chart 12, broken line)

Year	(A) Production Adjusted for the 2-Year, 3-1/2-Year and 6-Year Rhythms (Millions of Pounds) (From Table 16)	(B) 3-Year Moving Average of Column (A)
1911	0.39	---
1912	1.05	1.09
1913	1.84	1.91
1914	2.83	2.82
1915	3.79	4.04
1916	5.51	5.07
1917	5.92	5.91
1918	6.3	6.36*
1919	7.7	7.7 *
1920	11.7	11.6
1921	15.5	17.0
1922	23.9	22.9
1923	29.2	30.1
1924	37.3	39.8
1925	52.9	51.4
1926	63.9	62.9
1927	71.9	77.6
1928	96.9	89.5
1929	99.7	102.7
1930	111.5	115.6
1931	135.7	129.6
1932	141.7	146.2
1933	161.1	160.4
1934	178.5	176.4
1935	189.6	194.2
1936	214.5	208.2
1937	220.4	214.0
1938	207.1	225.0
1939	247.6	230.0*
1940	254.9	254.2*
1941	282.4	282.8
1942	311.1	310.8
1943	338.8	346.3
1944	389.0	392.8
1945	450.6	444.4
1946	493.7	485.2
1947	511.3	522.4
1948	562.3	---

*Values for 1918, 1919, 1939 and 1940 determined graphically rather than by computing the 3-year moving average in order to express the behavior of the underlying growth trend as discussed in the text, page 10.

Table 18

Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year, 3 1/2-Year and 6-Year Rhythms, Are of the 3-Year Moving Average of the Same

(See Chart 13, solid line)

Year	Percent
1911	---
1912	96.3
1913	96.3
1914	100.4
1915	93.8
1916	108.7
1917	100.2
1918	99.1
1919	100.0
1920	100.9
1921	91.2
1922	104.4
1923	97.0
1924	93.7
1925	102.9
1926	101.6
1927	92.7
1928	108.3
1929	97.1
1930	96.4
1931	104.7
1932	96.9
1933	100.4
1934	101.2
1935	97.6
1936	103.0
1937	103.0
1938	92.0
1939	107.7
1940	97.4
1941	99.9
1942	100.1
1943	97.8
1944	99.0
1945	101.4
1946	101.8
1947	97.9
1948	---

Table 19

Two-and-Three-Quarter-Year Periodic Table of the Percentages that the Production of Viscose Rayon Filament Yarn, Adjusted for the Effect of the 2-Year, 3 1/2-Year and 6-Year Waves, Are of the 3-Year Moving Average of the Same

(See Chart 13, broken line)

Base Year	Years After Base Year 1	2	3
1911	96.3	96.3	100.4
1914	93.8	108.7	100.2
1917	99.1	100.0	100.9
1920	91.2	(91.2)*	104.4
1922	97.0	93.7	102.9
1925	101.6	92.7	108.3
1928	97.1	96.4	104.7
1931	96.9	(96.9)*	100.4
1933	101.2	97.6	103.0
1936	103.0	92.0	107.7
Average Median**	97.5	95.8	102.8
Adjusted values***, 1911-1939 to base 1911	98.8	97.1	104.1
Values****, 1940-1948 to base 1939	99.5	99.5	100.5

* Figures in parentheses are repeated from the previous year.

** The average of the four middle values in each column.

*** The median has been raised to be symmetrical around the 100 per cent axis. In addition, positive values should be increased by 8 per cent and negative values should be decreased by 8 per cent of their difference from 100 per cent. Eight per cent is the correction factor used when computing the amplitude of a 2 3/4-year wave in the deviations from a 3-year moving average.

**** The 2 3/4-year wave from 1940 through 1948 is assumed to be present at 1/7 of the average 1911-1939 amplitude. See text page 9.

Table 20

Production of Viscose Rayon Filament Yarn Adjusted for the Effect of Perfectly Regular 2-Year, 2-3/4-Year, 3-1/2-Year and 6-Year Rhythms, Together with the Underlying Growth Trend

(See Chart 14)

Year	(A) Production Adjusted for the 2-Year, 3-1/2-Year and 6-Year Rhythms (Millions of Pounds)(From Table 16)	(B) The 2-3/4-Year Rhythm	(C) Production Adjusted for the 2-Year, 3-1/2-Year, 6-Year and 2-3/4-Year Rhythms (Millions of Pounds)	(D) Underlying Growth Trend (Values in Column C Smoothed Graphically) (Millions of Pounds)
1911	0.39	104.1	0.37	0.37
1912	1.05	98.8	1.06	1.06
1913	1.84	97.1	1.89	1.85
1914	2.83	104.1	2.72	2.78
1915	3.79	98.8	3.84	4.00
1916	5.51	97.1	5.67	5.15
1917	5.92	104.1	5.69	5.85
1918	6.3	98.8	6.4	6.3
1919	7.7	97.1	7.9	7.8
1920	11.7	104.1	11.2	11.2
1921	15.5	98.8	15.7	16.5
1922	23.9	104.1	23.0	22.5
1923	29.2	98.8	29.6	30.0
1924	37.3	97.1	38.4	39.5
1925	52.9	104.1	50.8	51.0
1926	63.9	98.8	64.7	64.0
1927	71.9	97.1	74.0	76.0
1928	96.9	104.1	93.1	90.0
1929	99.7	98.8	100.9	102.5
1930	111.5	97.1	114.8	115.0
1931	135.7	104.1	130.4	130.0
1932	141.7	98.8	143.4	146.0
1933	161.1	104.1	154.8	160.4
1934	178.5	98.8	180.7	178.0
1935	189.6	97.1	195.3	194.2

(Continued on next page)

Table 20 (Continued)

	(A)	(B)	(C)	(D)
Year	Production Adjusted for the 2-Year, 3-1/2-Year and 6-Year Rhythms (Millions of Pounds)(From Table 16)	The 2-3/4-Year Rhythm	Production Adjusted for the 2-Year, 3-1/2-Year, 6-Year and 2-3/4-Year Rhythms (Millions of Pounds)	Underlying Growth Trend (Values in Column C Smoothed Graphically) (Millions of Pounds)
1936	214.5	104.1	206.1	208.2
1937	220.4	98.8	223.1	218.0
1938	207.1	97.1	213.3	225.0
1939	247.6	104.1	237.8	230.0
1940	254.9	99.5	256.2	257.3
1941	282.4	99.5	283.8	287.8
1942	311.1	100.5	309.6	321.9
1943	338.8	99.5	340.5	359.9
1944	389.0	100.5	387.1	402.5
1945	450.6	99.5	452.9	450.2
1946	493.7	99.5	496.2	494.5
1947	511.3	100.5	508.8	533.3
1948	562.3	99.5	565.1	564.5

Column B based on Table 19.

Table 22

The 2-Year, 2-3/4-Year, 3-1/2-Year and 6-Year Rhythms and their Synthesis Projected to 1960 on (A) War and Post-War Amplitudes and (B) Pre-War Amplitudes

(See Chart 17)

Part A. War and Post-War Amplitudes

Year	2-Year Rhythm	3-1/2-Year Rhythm	6-Year Rhythm	2-3/4-Year Rhythm	Synthesis
1949	100.3	99.5	99.4	99.5	98.7
1950	99.7	100.2	98.2	100.5	98.6
1951	100.3	100.7	99.4	99.5	99.9
1952	99.7	99.9	100.6	99.5	99.7
1953	100.3	99.2	101.8	100.5	101.8
1954	99.7	100.6	100.6	99.5	100.4
1955	100.3	99.7	99.4	100.5	99.9
1956	99.7	99.5	98.2	99.5	96.9
1957	100.3	100.2	99.4	99.5	99.4
1958	99.7	100.7	100.6	100.5	101.5
1959	100.3	99.9	101.8	99.5	101.5
1960	99.7	99.2	100.6	99.5	99.0

Part B. Pre-War Amplitudes

Year	2-Year Rhythm	3-1/2-Year Rhythm	6-Year Rhythm	2-3/4-Year Rhythm	Synthesis
1949	103.8	95.5	97.5	97.1	93.8
1950	96.2	101.6	92.5	104.1	94.1
1951	103.8	106.8	97.5	98.8	106.8
1952	96.2	98.5	102.5	97.1	94.4
1953	103.8	92.3	107.5	104.1	107.2
1954	96.2	105.7	102.5	98.8	102.9
1955	103.8	* 90.7	97.5	104.1	* 101.9
1956	96.2	95.5	92.5	98.8	84.0
1957	103.8	101.6	97.5	97.1	99.9
1958	96.2	106.8	102.5	104.1	109.6
1959	103.8	98.5	107.5	98.8	108.6
1960	96.2	92.3	102.5	97.1	88.4

* See foot-note to Table 9.

Table 21

Composite Effect of the 2-Year, 2-3/4-Year, 3-1/2-Year and 6-Year Rhythms, and the Synthesis of these Waves with the Underlying Growth Trend

(See Chart 15, and Chart 16, broken line)

	(A)	(B)	(C)	(D)	(E)
Year	Synthesis of 2-Year, 3-1/2-Year and 6-Year Waves (from Table 15)	2-3/4 -Year Wave	Composite of All Four Waves	Underlying Growth Trend (from Table 20)	Synthesis of All Four Waves with the Trend (C x D)
1911	103.0	104.1	107.2	0.37	0.40
1912	104.2	98.8	102.9	1.06	1.09
1913	97.9	97.1	95.1	1.85	1.76
1914	85.0	104.1	88.5	2.78	2.46
1915	102.9	98.8	101.7	4.00	4.07
1916	105.3	97.1	102.2	5.15	5.26
1917	109.9	104.1	114.4	5.85	6.69
1918	91.0	98.8	89.9	6.3	5.66
1919	107.0	97.1	103.9	7.8	8.1
1920	86.0	104.1	89.5	11.2	10.0
1921	96.6	98.8	95.4	16.5	15.7
1922	100.1	104.1	104.2	22.5	23.4
1923	119.2	98.8	117.8	30.0	35.3
1924	97.2	97.1	94.4	39.5	37.3
1925	93.4	104.1	97.2	51.0	49.6
1926	94.1	98.8	93.0	64.0	59.5
1927	97.9	97.1	95.1	76.0	72.3
1928	94.2	104.1	98.1	90.0	88.3
1929	113.4	98.8	112.0	102.5	114.8
1930	105.3	97.1	102.2	115.0	117.5
1931	99.6	104.1	103.7	130.0	134.8
1932	82.1	98.8	81.1	146.0	118.4
1933	107.0	104.1	111.4	160.4	178.7
1934	95.3	98.8	94.2	178.0	167.7
1935	106.5	97.1	103.4	194.2	200.8
1936	100.1	104.1	104.2	208.2	216.9
1937	108.1	98.8	106.8	218.0	232.8
1938	87.7	97.1	85.2	225.0	191.7
1939	93.4	104.1	97.2	230.0	223.6
1940	100.9	99.5	100.4	257.3	258.3
1941	101.8	99.5	101.3	287.8	291.5
1942	99.8	100.5	100.3	321.9	322.9
1943	99.9	99.5	99.4	359.9	357.7
1944	98.6	100.5	99.1	402.5	398.9
1945	99.6	99.5	99.1	450.2	446.1
1946	99.5	99.5	99.0	494.5	489.6
1947	102.7	100.5	103.2	533.3	550.4
1948	100.0	99.5	99.5	564.5	561.7

Column B based on Table 19.

A COMPOSITE INDEX OF LYNX ABUNDANCE, 1735--1950

By Leonard W. Wing

IT seems redundant to repeat that for cycle study particularly, nothing will substitute for a long series of data. Confidence grows with the length of records, though numerous short time records will reinforce each other. The length of a record may be increased sometimes for cycle studies by "splicing" together various elements not otherwise continuous.

By splicing together and supplementing the related (though not completely homogeneous) series of data on the number of lynx (**Lynx Canadensis**) caught by the Hudson's Bay Company trappers, an **index** of lynx abundance becomes available for a 216-year period (1735—1950).

The figures have been taken largely from the paper by Charles Elton and Mary Nicholson, "The Ten-Year Cycle in Numbers of the Lynx in Canada," published in the Journal of Animal Ecology (1942, 11:215 - 244). This paper gathers together and collates several published records of other writers and adds to it some original transcriptions from the Hudson's Bay Company records. The several sources have been thoroughly evaluated by Elton and Nicholson, and we may have full confidence in their accuracy as presented. The adjustments in the respective figures to prepare this index appear as footnotes in the appropriate places. In addition, the source of each datum appears in the footnotes and in the table.

A serious discontinuity occurs in these figures between 1820 and 1821 because of the merger at this time of the Hudson's Bay Company and the great North West Company. Lynx returns of the old Hudson's Bay Company which had fluctuated about a relatively stable trend line for seventy-five years or more, suddenly jumped upward to oscillate about a trend line relatively stable at about 10 times the old values for the seventy-five years to follow.

The two series were therefore spliced by multiplying the old value by a suitable constant to equate the trend of pre-merger and post-merger activities.

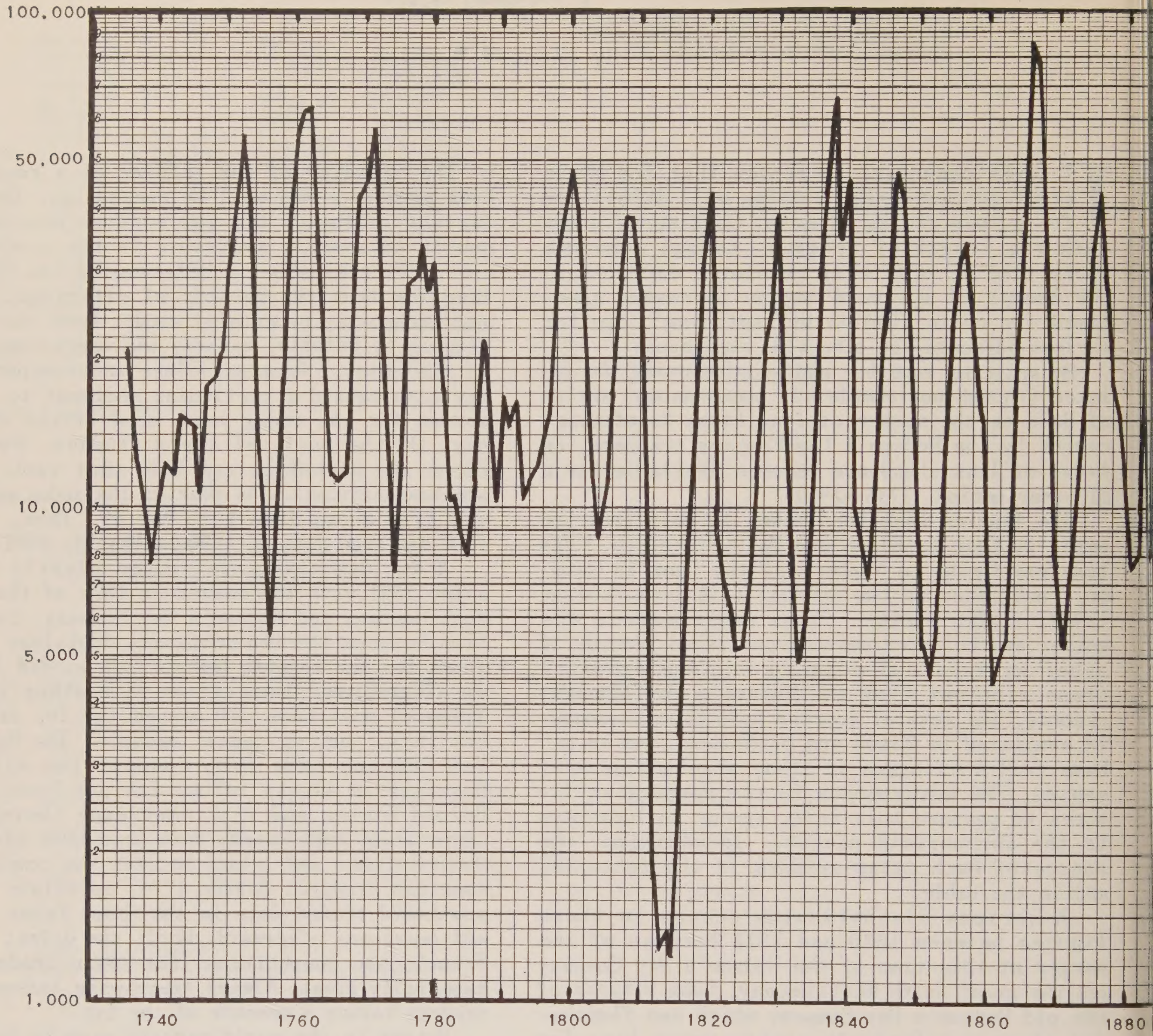
No one would claim that this method gives an absolutely true measure of Lynx abundance between the period before and after the merger, but it is certainly nearer the truth than the unadjusted figures, and, if the discontinuity and possibility of erroneous adjustment be kept in mind, serves adequately as an index for cycle determination.

The validity of fur returns as a record of Lynx abundance may well be considered, for many factors influence the fur returns besides the number of animals available in the woods. One source of confusion is determining the year of trapping from the records of offerings. Elton and Nicholson, by careful study, have listed all figures by **Outfits**, usually the operational year of the catch. Because delays in transportation may have caused a particular shipment to be recorded for the wrong year, some errors may occur. On the basis of their studies, however, Elton and Nicholson conclude that such errors are insignificant. The year of the index usually ran from about June 1 to May 31. Thus, outfit 1890 ran from June 1, 1890 to May 31, 1891.

A decided change in volume clearly occurs after 1821 with the merger in 1820 of the North West Company and Hudson's Bay Company. Competition between the two companies doubtless influenced the fur reports before 1820 as did lack of it afterwards. Competition with other traders likewise must have influenced the fur returns, but this, too, we cannot measure. The Hudson's Bay Company came into competition with the Russians in Alaska before its purchase by the United States and with Americans thereafter. Competition must surely have been keen along the Pacific Coast and inland between the company and American traders. Before 1776, colonists to the southward traded furs in the Great Lakes region and Americans afterward. Until the defeat of the French, the competition from their traders was especially great. Always there were independent traders taking a measure of the fur.

Prices in the world markets seem to have had little influence, for the amount paid the trapper seems to have remained static for long periods despite fluctuations in the prices at sales. Because the trappers took all furs, more or less as they came, the relative value and abundance of the various furs probably played a part in the catch trade. An Indian loaded down with furs would perhaps be expected to discard or postpone sale of a less valuable skin in his pack to make room for any newly caught one of higher value.

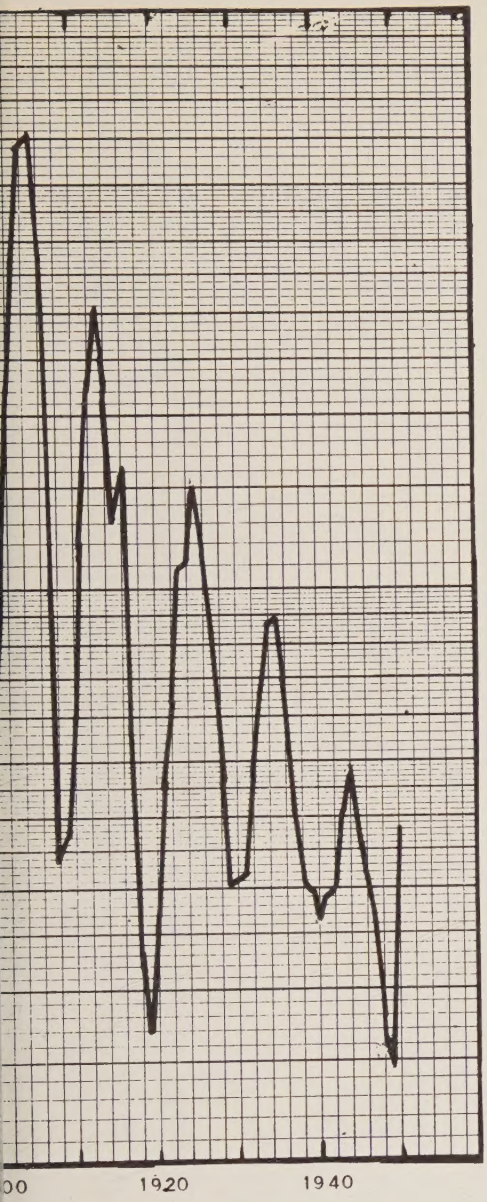
The early trading seems to have been largely up and down the main rivers, and variations in trade routes would more likely influence the trade by district and trading post rather than in the total as reported in the index.



trade equipment compared to earlier more primitive equipment

But none of these influences has an appearance of cyclic behavior, though they may introduce distortions to relative values and to a cycle at the point of distortion. Thus, if an entire year's shipment of fur were late one year, it might double the next year's totals and distort the amplitude of a cycle at that point. But the cycle would continue in succeeding years as before the year of distortion.

But the welfare and warfare of the Indians played a part. A great smallpox epidemic about 1778 influenced adversely the catch reported for at least fifteen years. Probably also, intertribal conflict influenced the trade. The coming of settlement by the white man clearly reduced the overall catch by eliminating the greater part of the trapping grounds to the south, and this may account for the decline of the trend after 1904. Presumably the trapping to the north of settlements has been influenced by increased trapping efficiency through use of trade equipment compared to earlier more primitive equipment.



Footnotes

a 1735--1786 (except 1778), from Elton and cholson, Table 5, Hudson's Bay Company totals.

b Interpolation for 1778 on basis of York ctory totals 1735--1777 in relation to total r Northern Department. Lynx skins total 98,863 r Northern Department and 42,473 for totals her than York Factory (ratio 2.32767). Cor-ction factor of 2.32767 applied to totals for urchill River, Moose River, and Albany River give 2,912 for 1778.

c 1787--1793, from Elton and Nicholson, Table Poland figures.

d 1794--1799, from Elton and Nicholson, Table Hudson's Bay Company totals.

e 1800--1820 (except 1808--1809), from Elton and Nicholson, Table 5, Poland figures.

f 1808--1809, Elton and Nicholson suggest an anomoly for 1808 with unusual rise in 1809. Hence, data for 1808--1809 prorated 3,653 for each year.

g 1821--1847, from Elton and Nicholson, Table 1, Poland figures.

h 1832--1836, Elton and Nicholson indicate confusion in records (noted also by Poland). Hence, total for period prorated on basis of Northern Department figures of Table 4. Presumably Northern Department figures fairly representative of years:

	Northern Department		Poland Figures	
	Skins	Per Cent	Total	Adjusted
1832	4,619	12.52	870	7,317
1833	3,116	8.45	14,255	4,938
1834	3,894	10.56	6,990	6,171
1835	6,311	17.11	4,440	9,999
1836	18,941	51.36	31,887	30,016
Total	36,881		58,442	

i 1848--1909, from Elton and Nicholson, Table 1. Jones figures reported to be more reliable than Poland figures. They agree with Hudson's Bay Company figures for 1851--1875 and so are used for 1848--1909.

j 1910--1911, from Elton and Nicholson, Table 1. Only Hewitt figures given in these years.

k 1912--1925 (except 1914), from Elton and Nicholson, Table 2. Hudson's Bay Company figures; fiscal year shifted to end May 31, a shift of one month. Not deemed possible to adjust figures nor believed a significant change.

l 1914; Prorated change between 1913 and 1915 used for 1914.

m 1926--1952, Dominion figures from Elton and Nicholson, Table 2, and Dominion Bureau of Statistics.

n 1735--1820, data of first column adjusted to trend of remainder of series as follows: First seventy-five years (1735--1809), total 160,279; first seventy-five years after merger of Hudson's Bay Company and North West Company (1822--1895), total 1,685,687. This gives ratio of 10.5172, which ratio is applied to 1735--1820 data to balance trend of post-merger activities. The trend of the data after 1820 roughly parallels (Figure 1) the trend before 1820 but lies above it. The increase of the earlier returns by a constant ratio (10.5172) has the effect of raising the curve of the earlier figures so that the trend before and after 1820 are in relative balance (Figure 1). This will not change the cycles importantly as they are measured from the trend rather than from an absolute scale.

o 1926--1950, Dominion figures adjusted by correction factor of .39546, the ratio of Dominion and Hudson's Bay figures during overlapping years of 1919--1925. (Total Hudson's Bay figures 53,030; total Dominion figures 134,097. Ratio of .39546 used as correction factor.)

p 30,000 also given for this year.

q Brackets as in Elton and Nicholson.

MAR 3 1953

TABLE 1

Outfit (year of catch)	Hudson's Bay Co. Totals[1]	Poland Figures[w]	Jones Figures[x]	Hewitt Figures[x]	Hudson's Bay Co. Figures[y]	Dominion Bureau of Statistics[z]	Actual Figures Used to Form Index	Lynx Index
1735	[a]1,958						[a]1,958	[n]20,593
1736	1,464						1,464	15,397
1737	1,111						1,111	11,685
1738	899						899	9,455
1739	740						740	7,783
1740	990						990	10,412
1741	1,164						1,164	12,242
1742	1,119						1,119	11,769
1743	1,444						1,444	15,187
1744	1,410						1,410	14,829
1745	1,399						1,399	14,714
1746	1,022						1,022	10,749
1747	1,699						1,699	17,869
1748	1,760						1,760	18,510
1749	1,947						1,947	20,477
1750	2,846						2,846	29,932
1751	4,010	4,009					4,010	42,174
1752	5,359	7,179					5,359	56,362
1753	4,197	4,198					4,197	44,141
1754	1,410	1,444					1,410	14,829
1755	956	838					956	10,054
1756	530	631					530	5,574
1757	918	917					918	9,655
1758	1,738	1,881					1,738	18,279
1759	3,842	3,842					3,842	40,407
1760	5,296	5,338					5,296	55,699
1761	5,820	5,820					5,820	61,210
1762	6,017	6,000					6,017	63,282
1763	2,892	3,005					2,892	30,416
1764	1,759	1,771					1,759	18,500
1765	1,138	1,138					1,138	11,969
1766	1,086	1,088					1,086	11,422
1767	1,129	1,128					1,129	11,874
1768	2,507	2,508					2,507	26,367
1769	4,104	4,012					4,104	43,163
1770	4,329	4,225					4,329	45,529
1771	5,471	5,463					5,471	57,540
1772	2,299	2,301					2,299	24,179
1773	1,727	1,744					1,727	18,163
1774	707	705					707	7,436
1775	1,167	1,157					1,167	12,274
1776	2,735	2,823					2,735	28,765
1777	2,748	2,478					2,748	28,901
1778	[b]?	1,245					[b]2,912	30,626
1779	2,619	3,168					2,619	27,545
1780	2,950	2,966					2,950	31,026
1781	1,652	1,553					1,652	17,374
1782	980	960					980	10,307
1783	993	980					993	10,444
1784	834	822					834	8,771
1785	758	801					758	7,972
1786	1,089	1,080					1,089	11,453
1787		[c]2,050					[c]2,050	21,560
1788		1,550					1,550	16,302
1789		970					970	10,202
1790		1,603					1,603	16,859
1791		1,400					1,400	14,724
1792		1,546					1,546	16,260
1793		989					989	10,402
1794	[d]1,092	1,102					[d]1,092	11,485
1795	1,160	1,149					1,160	12,200
1796	1,307	1,625					1,307	13,746
1797	1,471	1,541					1,471	15,471
1798	2,878	2,269					2,878	30,269
1799	3,732	3,708					3,732	39,250
1800		[e]4,495					[e]4,495	47,275
1801		3,658					3,658	38,472
1802		2,083					2,083	21,907
1803		1,091					1,091	11,474
1804		820					820	8,624
1805		1,052					1,052	11,064
1806		1,588					1,588	16,701
1807		2,788					2,788	29,322
1808		[f]277					[f]3,653	38,419
1809		[f]7,029					[f]3,653	38,419
1810		2,593					2,593	27,271
1811		1,884					1,884	19,814
1812		167					167	1,756
1813		122					122	1,283
1814		131					131	1,378
1815		116					116	1,220
1816		347					347	3,649
1817		845					845	8,887
1818		1,533					1,533	16,123
1819		2,901					2,901	30,510
1820		4,128					4,128	[h]43,415
1821		[g]8,986		9,000			[g]8,986	8,986
1822		7,173		4,000			7,173	7,173
1823		6,456		3,000			6,456	6,456
1824		5,104		2,000			5,104	5,104
1825		5,161		3,000			5,161	5,161
1826		7,254		7,000			7,254	7,254
1827		11,550		10,000			11,550	11,550
1828		20,558		21,000			20,558	20,558
1829		24,611		25,000			24,611	24,611
1830		38,200		36,000			38,200	38,200
1831		16,347		15,000			16,347	16,347
1832		[h]870		3,000			[h]870	[h]7,317
1833		[h]14,255		14,000			[h]14,255	[h]4,938
1834		[h]6,990		5,000			[h]6,990	[h]6,171
1835		[h]4,440		5,000			[h]4,440	[h]9,999
1836		[h]31,887		29,000			[h]31,887	[h]30,016
1837		45,152		44,000			45,152	45,152
1838		66,691		63,000			66,691	66,691
1839		35,843		35,000			35,843	35,843
1840		45,143		45,000			45,143	45,143
1841		10,034		10,000			10,034	10,034
1842		8,247		5,000			8,247	8,247
1843		7,173		6,000			7,173	7,173
944		10,359		10,000			10,359	10,359

Outfit (year of catch)	Hudson's Bay Co. Totals[1]	Poland Figures[w]	Jones Figures[x]	Hewitt Figures[x]	Hudson's Bay Co. Totals[1]	Dominion Bureau of Statistics[z]	Actual Figures Used to Form Index	Lynx Index
1845		21,180		17,000			21,180	21,180
1846		31,062		29,000			31,062	31,062
1847		47,065		44,000			47,065	47,065
1848		43,253	[i]43,738	41,000			[i]43,738	43,738
1849		20,604	20,353	19,000			20,353	20,353
1850		9,305	8,519	10,000			8,519	8,519
1851		6,722	5,361	8,000			5,361	5,361
1852		4,850	4,552	7,000			4,552	4,552
1853		4,907	5,682	5,000			5,682	5,682
1854		10,764	11,358	10,000			11,358	11,358
1855		21,511	23,362	20,000			23,362	23,362
1856		32,264	31,642	[p]31,000			31,642	31,642
1857		33,038	33,757	32,000			33,757	33,757
1858		27,460	23,226	25,000			23,226	23,226
1859		15,968	15,178	18,000			15,178	15,178
1860		7,927	7,272	11,000			7,272	7,272
1861		4,616	4,448	4,000			4,448	4,448
1862		4,570	4,926	5,000			4,926	4,926
1863		4,760	5,437	6,000			5,437	5,437
1864		17,044	16,498	16,000			16,498	16,498
1865		34,732	35,971	35,000			35,971	35,971
1866		68,097	76,556	77,000			76,556	76,556
1867		70,372	68,392	67,000			68,392	68,392
1868		39,119	37,447	40,000			37,447	37,447
1869		19,992	15,686	13,000			15,686	15,686
1870		8,806	7,942	7,000			7,942	7,942
1871		5,679	5,123	5,000			5,123	5,123
1872		4,839	7,106	9,000			7,106	7,106
1873		10,045	11,250	13,000			11,250	11,250
1874		17,849	18,774	18,000			18,774	18,774
1875		18,868	30,508	29,000			30,508	30,508
1876		43,575	42,834	41,000			42,834	42,834
1877		37,490	27,345	28,000			27,345	27,345
1878		21,291	17,834	17,000			17,834	17,834
1879		14,767	15,386	15,000			15,386	15,386
1880		10,053	9,443	8,000			9,443	9,443
1881		7,581	7,599	5,000			7,599	7,599
1882		8,016	8,061	8,000			8,061	8,061
1883		27,119	27,187	27,000			27,187	27,187
1884		51,414	51,511	50,000			51,511	51,511
1885		73,878	74,050	74,000			74,050	74,050
1886		78,555	78,773	78,000			78,773	78,773
1887		33,720	33,899	37,000			33,899	33,899
1888		18,726	18,886	17,000			18,886	18,886
1889		11,445	[q](11,520)	12,000			11,520	11,520
1890			8,352	7,000			8,352	8,352
1891			8,660	6,000			8,660	8,660
1892			12,902	12,000			12,902	12,902
1893			20,331	20,000			20,331	20,331
1894			36,853	36,000			36,853	36,853
1895			56,407	55,000			56,407	56,407
1896			39,437	37,000			39,437	39,437
1897			26,761	26,000			26,761	26,761
1898			15,185	15,000			15,185	15,185
1899			4,473	5,000			4,473	4,473
1900			5,781	6,000			5,781	5,781
1901			9,117	8,000			9,117	9,117
1902			19,267	18,000			19,267	19,267
1903			36,116	37,000			36,116	36,116
1904			58,850	57,000			58,850	58,850
1905			61,478	61,000			61,478	61,478
1906			38,501	32,000			38,501	38,501
1907			9,704	7,000			9,704	9,704
1908			3,410	2,000			3,410	3,410
1909			3,774	2,000			3,774	3,774
1910				[j]6,000			[j]6,000	6,000
1911				12,000			12,000	12,000
1912					[k]22,877		[k]22,877	22,877
1913					30,991		30,991	30,991
1914					?		?	[l]22,404
1915					13,817		13,817	13,817
1916					16,259		16,259	16,259
1917					5,606		5,606	5,606
1918					2,325		2,325	2,325
1919					1,695	9,499	1,695	1,695
1920					2,571	6,509	2,571	2,571
1921					4,599	11,673	4,599	4,599
1922					6,028	17,317	6,028	6,028
1923					10,682	26,437	10,682	10,682
1924					11,349	29,608	11,349	11,349
1925					16,106	33,054	16,106	16,106
1926						[m]28,706	[m]28,706	[o]11,352
1927						21,369	21,369	8,451
1928						11,604	11,604	4,589
1929						7,621	7,621	3,014
1930						7,976	7,976	3,154
1931						8,454	8,454	3,343
1932						11,932	11,932	4,719
1933						16,799	16,799	6,643
1934						22,014	22,014	8,706
1935						22,456	22,456	8,880
1936						17,539	17,539	6,936
1937						10,538	10,538	4,167
1938						8,109	8,109	3,207
1939						7,473	7,473	2,955
1940						6,642	6,642	2,627
1941						7,109	7,109	2,811
1942						7,606	7,606	3,008
1943						10,197	10,197	4,033
1944						12,329	12,329	4,876
1945						9,338	9,338	3,693
1946						8,151	8,151	3,223
1947						6,582	6,582	2,603
1948						4,110	4,110	1,625
1949						3,733	3,733	1,476
1950						9,663	9,663	3,821

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[v] Elton and Nicholson, Table 5.

[w] Elton and Nicholson, Table 5, 1735--1820; Table 1, 1821--1889.

[x] Elton and Nicholson, Table 1.

[y] Elton and Nicholson, Table 2.

[z] Elton and Nicholson, Table 2, and from Bureau